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EXPLORING EXTERNAL SUPPLY CHAIN RISK IN MARITIME TRANSPORTATION

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ABSTRACT

This paper investigates the monetary impact modern piracy has had on the Oil, Automobile, and Food industries, and the implications for companies with operations in regions with piracy. By analyzing the monetary impact of piracy across different industries, one can gain a better understanding of how the costs of modern piracy trickle down to affect companies with import/export operations in the region. Factors taken into account for the purposes of this analysis include the monetary value of shipments, volume of shipments, product attributes, ship type, regional market share, as well as local market conditions.

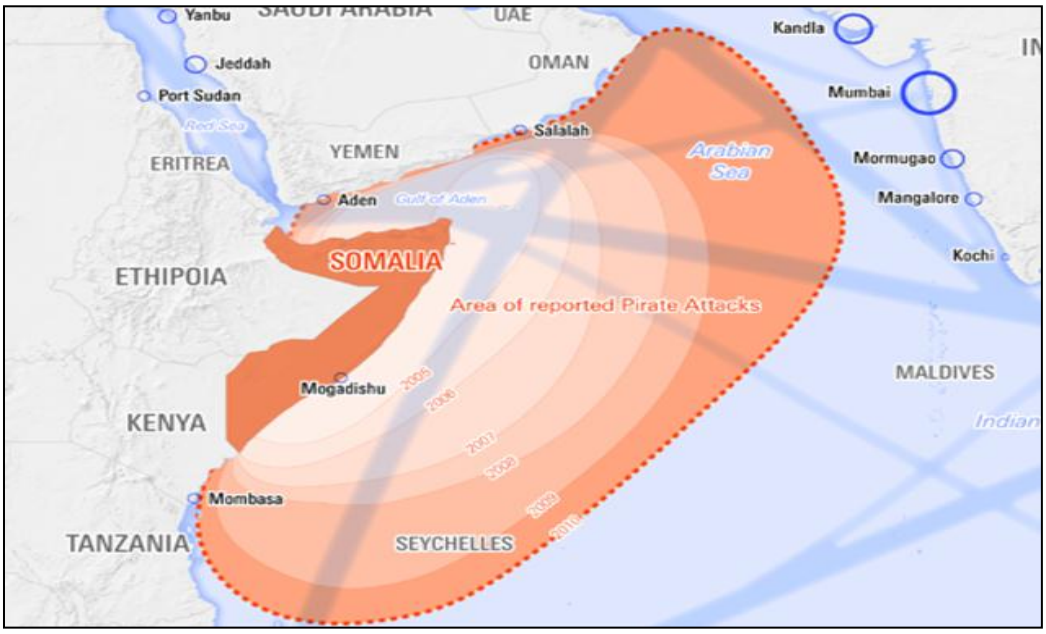
After conducting analysis using publically available information to estimate the relative monetary impact on revenue for companies from the aforementioned industries, the findings indicate that industries with high value shipments are most susceptible to piracy risk, and are impacted the most by pirate activity. Specifically, the Oil industry was affected to the largest extent by piracy, followed by the Food industry and the Automobile industry. However, on a company level, a firm's expected piracy risk depended on their relative market share in the region more so than on their industry. Furthermore, the analysis indicates that the nature of the cargo and the standard deviation of piracy rates per ship type need to be taken into account before a firm can realistically determine the extent of piracy risk. Cargo insurance and risk minimization strategies are also discussed briefly in this paper.

Table of Contents

Chapter 1: Introduction

Background

Maritime piracy has become quite prevalent in regions surrounding the Gulf of Aden in recent years, as commercial shipping increasingly comes under attack from a threat that is growing in both size and sophistication. International trade growth, coupled with the growing worldwide demand for energy, has made the shipping lanes which traverse the Arabian Sea and Indian Ocean as critical as ever to the workings of the global economy. Correspondingly, pirates have taken advantage of the unique regional combination of relatively weak governmental control, sparse maritime supervision, and the lack of legitimate local job opportunities to recruit and entice additional recruits into the organizations. The economic viability of piracy as an industry is further solidified by the predictable, plentiful, and profitable nature of commercial shipping in the region, much of which is forced by geographical constraints to maintain their courses despite the risk. Overall, the continued weakness of regional governments in enforcing the rule of law and low standards of living of local populations ensure that piracy will remain a factor in the region for many years to come, if not for the foreseeable future.



Map 1: Piracy Region in the Arabian Sea

Whereas the net economic impact of modern piracy and the havoc it has wreaked on the maritime shipping industry has been well documented by think-tanks and government groups worldwide, the losses incurred by companies not directly responsible for the cost of piracy has received little attention. Organizations such as Geopolicity, the International Chamber of Commerce, and even the Rand Corporation have investigated the piracy phenomenon, but none have investigated the downstream costs of piracy as it relates to specific companies and industries. Although the complex network of insurance policies and carrier contracts promises that companies utilizing maritime transportation to move product will feel very little impact from piracy on their bottom lines, it would be naïve to think that the piracy phenomenon has not had any downstream effects on the profitability of these companies. It is to investigate the downstream effects on company revenue stemming from supply chain disruptions due to piracy that this paper is dedicated.

Purpose

By collecting and analyzing pertinent piracy statistics and industry information, an extrapolation of the findings to simulate effects at the company-level stemming from piracy can reveal the monetary impact of piracy on company profitability. In addition, methods to minimize company-level risk can be determined by identifying specific risk factors and their contribution to overall risk. With this information, companies with current import/export needs in the Middle Eastern region can gain visibility to the potential effects of piracy on their revenue, and find ways to reduce their exposure to such unsystematic risk. For the purposes of this paper, three industries have been chosen (Oil, Automobile, and Food) which best represent a cross-section of the main product categories transported using maritime shipping. The industry-wide impact of piracy will be calculated and the company-level revenue impact of piracy will be estimated for

these three industries in an effort to find a comparative cost of piracy. The findings will provide insight on the relative impact of piracy on each industry, and the severity of the impact on revenue for companies in those industries. Ultimately, this paper will seek to identify a methodology by which companies can classify their potential piracy risk and to provide a basis for quantifying that risk going forward.

Chapter 2: Literature Review

Previous Research

Ample research has already been conducted on the macroeconomic impact of piracy on global trade. Previously published research by The Hong Kong Polytechnic University, *The Impacts of Maritime Piracy on Global Economic Development* (Fu, Ng & Lau, 2008) place the net economic cost of piracy in the absence of government intervention at an incredible $25 billion(p.218). This figure has been cited as justification for the increasing international resources devoted to combating piracy via both military and private means. While $25 billion seems to be the upper estimate in the current field of maritime piracy research, most economic reports have placed the costs of piracy squarely in the billions. *The Economic Costs of Maritime Piracy* (One Earth Future Foundation, 2010) sought to identify the costs associated with piracy by breaking the costs down into separate components of direct and indirect costs. These costs were calculated individually, and then tallied to give a total "price tag" for piracy of $7-12 billion a year. The most recently published comprehensive study of piracy (Economics of Piracy, 2011) built upon the research already established by the One Earth Future Foundation. Utilizing additional piracy data collected in the first quarter of 2011, and more stringent criteria and confidence intervals, Geopolicity was able to place the estimated economic costs of piracy between $4.9-8.3 billion USD as the lower and upper bounds. Given that this is the latest and most concise figure of the net economic effects of piracy available, this paper will use the figure presented by *Economics of Piracy* as the basis for macroeconomic cost assumptions.

Other published research in the maritime piracy field explored the economic incentives of piracy and sought to explain the economic incentives and reasons behind the burgeoning industry. *Freakonomics of Maritime Piracy* (Kraska, 2010), detailed the various economic

incentives and factors the piracy industry relies on for its continued growth. These include, but are not limited to, the extremely lucrative career prospects for pirates when compared to other local means of employment, the relative sense of law and order pirate organizations bring to communities where they operate, and the importance of maritime trade through the Gulf of Aden region which contributes to a high degree of risk tolerance amongst shipping companies. A congressional report titled *Maritime Piracy: Reasons, Dangers and Solutions* (Chalk, 2009) detailed similar findings. Although these papers did not directly relate to the purposes of this paper, they are nonetheless beneficial for the understanding of the social, economic and political framework within which maritime piracy functions.

Lastly, the topic of modern day maritime piracy has not been the sole playing field of government think tanks and university researchers. There have also been previous theses published on subject, with that of *The Influence of Modern Piracy on Maritime Commercial Transport* (Van der Meijden, 2008) being the most comprehensive. In addition to exploring the economic implications of piracy, however, Van der Meijden went one step further and attempted to quantify the direct costs to the shipping industry as a result of piracy. The amount presented, $250 million annually, was a miniscule figure when compared to the total macroeconomic costs of the piracy phenomenon. Nevertheless, it was the first academic research to address the costs of piracy for a specific industry, and also investigated the possibility of costs being passed on from the carriers to their customers.

Given the current field of publically available research, it can be seen that there is a paucity of information about the impact piracy has had on specific industries. Furthermore, no research to date has attempted to calculate the costs of piracy as they relate to a shipper. It is these two areas specifically on which this paper will seek to provide additional research.

Chapter 3: Research Methodology

Industry Choice

Three different industries have been chosen for which the monetary effects of piracy will be investigated. The choices of Oil, Automobile, and Food industries were made by taking into account the type, size, and nature of ships used to transport products in the above industries with an effort to gain the best cross-section of ship types. The following matrix shows the use of ship types across the three industries:

	Oil	Automobiles & Accessories	Food & Commodities
Tankers	**X**		
Container Ships & Roll-on Roll-off		**X**	
Bulk Carriers			**X**

The choices were also made on the basis of the volume of international trade constituted, and monetary value of the products themselves. An effort was made to choose industries that were independent from one another, so that each is insulated from market fluctuations in the other industries.

Oil Industry

World oil production in 2010 numbered at about 82 million barrels per day. With the average U.S. domestic prices of crude oil at $87.04 per barrel (InflationData: Historical Oil Prices Table, 2012), this translates to an annual estimated world output worth $2.6 trillion. Since this number only takes into account the value of unprocessed crude oil, and also excludes other sources of fuel such as natural gas, it can be assumed that the real value of the oil industry is much higher. The immense volume of oil exports, its importance to the world economy, as well

as the fact that the Middle East is the largest oil producing and exporting region in the world, contributed to the choice of Oil as a representative industry in this analysis.

ExxonMobil has been chosen as a specific example of a firm within the oil industry, given its reputation as the largest of the Big Six oil companies and its extensive global operations. Although the company only makes up for roughly 3% of global oil production (State-owned firms such as Sinopec, Gazprom and Petrobras generally dominate the industry), the public availability of company information make it a preferable candidate for our company-level analysis.

Automobile Industry

Being one of the most common (and most expensive) examples of manufactured goods, automobiles make up a large portion of manufactured goods around the world. With 52.9 million cars produced in 2008, the extensive supply chain for automobiles stretches around the globe. Although the recent economic downturn has undoubtedly affected automobile sales (the peak of automobile production in 2007 numbered 54.9 million), it can be reasonably assumed that car production remains in the 50 million range given the recovery of major world economies from the recession. Given the average price of automobiles and historical sales data, the world car market would be valued at over $2.14 trillion dollars.

Toyota has been chosen as the example firm within the automobile industry due to its large market share and popularity in the Middle East region. The large number of Toyota sales in the Middle East comprising 31% of the local market, coupled with a lack of local manufacturing facilities and the need to import finished goods, makes Toyota a prime example of a company within this industry that stands to gain from a deeper understanding of the overarching effects of piracy on the business.

Food Industry

Being the most diffused of the three industries chosen for this analysis, the food industry is difficult to judge from a revenue point of view due to the various firms, corporations, cooperatives and governments involved in the production and distribution of food products. Even with the scarcity of information, the packaged foods industry alone is estimated by some analysts to be worth $4 trillion dollars globally (Global Food Markets, 2012). The dearth of local agricultural output in the Middle East, coupled with the relative affluence of the population there, make food imports a very high volume, high value import category for the region.

Nestlé has been chosen as the example firm within the food industry due to its position as the largest packaged foods company in the world. Nestlé produces a number of products in a wide range of food and beverage categories, ranging from infant formula to nutritional supplements and water. Thus, it is reasonable to assume that Nestlé represents the categories within the food industry more accurately than similar sized firms that specialize in particular types of food or beverages. Additionally, readily available information on company revenues and operations makes Nestlé the logical choice for a company-level analysis.

Definitions

This section details and clarifies the terminology that will be used in this paper. Some terms will have multiple uses; however, these will be defined in the paper itself if the usage strays from the definition below:

1. Shipper – A company that imports or exports products overseas. Generally does not own or operate ships.
2. Carrier – Company that provides maritime transportation service. Owns and operates ships.

3. TEU – Twenty-foot equivalent units. The standard unit of measurement for cargo ship containers.

4. DWT – Deadweight Ton. The standard unit of measurement for bulk carrier capacity.

5. Barrel – Standard unit of measure for crude oil. Contains about 42 gallons of crude.

6. Cargo – Goods being carried within the ship. In this case, cargo generally refers to crude oil, automobiles, or foodstuffs.

7. Tankers – Oil tankers. Ships equipped with tanks to hold liquid cargo. Capacity is measured in barrels, but ship size can sometimes be given in DWT as well.

8. Container ships – Ships made for the carrying of shipping containers. Generally carries cargo in TEU units, but certain models are modified to carry portions of liquid or bulk cargo as well. Can come equipped with cranes for use in loading/unloading.

9. Bulk carriers – Ships modified for the carrying of 'bulk' unpackaged cargo. Cargo usually consists of solid-state matter that is transported and distributed according to weight or volume, such as coal, iron ore, grains, and other foodstuffs. Are generally equipped with conveyer belt system for the automated loading and unloading of bulk cargo.

10. Roll-on Roll-off ships (ro-ro) – Ships made for the transportation of vehicles. Ships come equipped with ramps to facilitate the loading and unloading of vehicles.

11. Cargo ships – In this context, cargo ships will refer to all types of cargo carrying vessels regardless of classification.

12. Incident (Piracy) – Taken to mean the occurrence of a pirate attack or attempt to capture the ship.

13. Capture (Piracy) – The successful capture of a ship by pirates. A successful capture is characterized by complete control of the ship and crew by pirates. Partial captures where the

crew manages to evade the pirates, or where pirates are unable to gain access to the ship controls, are counted as Incidents (see above).

14. Hijacking – See Capture (Piracy)

Assumptions

Before explaining the research methodology used to reach the findings in this paper, it is important to establish the assumptions taken in the calculations and analysis, and the reasoning behind them: A few general assumptions have been made that form the basis of the cost calculations and analysis to follow:

A1. The first of these assumptions is that traffic to and from the Strait of Hormuz are subject to the highest level of piracy risk, as these ships have the fewest options for avoiding piracy prone regions due to their origin and destination ports. To illustrate the financial effect of piracy on companies doing business in this region, six countries have been selected as representative of the region: Saudi Arabia, the United Arab Emirates, Qatar, Kuwait, Iraq, and Iran (hereafter referred to collectively as "the Middle East"). Due to the location of the national seaports for these six countries, the majority of ocean freight would have to pass through the Strait of Hormuz to reach its destination. Import and export information, national sales data, and market share information from these six countries make up the data used for the industry cost calculations.

A2. The assumption is made that all pirate attacks are made against fully laden ships, and that ships traveling empty are safe from piracy risk. This assumption was made due to the fact that fully laden ships travel at a slower speed than empty ships, thus making maneuvering more difficult in case of pirate attack. Additionally, since pirates usually board ships by approaching

on fast skiffs or motor boats, then throwing ropes or ladders over the main deck, the deck height from the sea surface is an important factor for cargo ships defending against pirates. Fully laden ships have a shorter distance between their main deck and the sea surface, making a boarding action easier.

A3. It is assumed that any cargo that pirates capture along with the ship will remain in the ship and will be released with the ship after ransom negotiations, and that pirates will not pilfer or siphon off the cargo for their own use. Although there have been situations where pirates have taken cargo for their own use (in most cases the cargo is taken to replace weapons, boating equipment, food, etc.), the assumption is made that cargo will not be taken in order to facilitate cost calculations. In the same vein, the assumption is made that there will be no damage caused to the ship by a pirate attack or a successful capture by pirates. Additionally, though there are varying sizes of each kind of ship traversing the seas, it is assumed for the purposes of this analysis that all sizes and classes of ships within each classification are equally susceptible to pirate attack, and equally likely to be captured.

A4. Insurance is not taken into account for the cost calculations, due to the complex relationships and the plethora of clauses that surround maritime risk underwriting. The costs calculated for each industry/company are representative of the out-of-pocket costs an industry or firm would incur if insurance is not purchased. Further discussion of insurance policies and their impact on piracy costs are discussed in Section VI.

A5. Last but not least, it is assumed that the average of piracy statistics from the past four years (2008 through 2011) will be representative of future piracy rates. The total macroeconomic costs of piracy, in the order of $4.9 to $8.3 billion dollars (Economics of Piracy, 2011) is also

accepted as a representative measure for future macroeconomic costs of piracy, and provides a context against which the piracy cost to each industry can be compared.

Oil Industry Assumptions

B1. To provide a standard for analysis of the oil industry, it is assumed that 90% of oil exports from the Middle East are exported via oil tanker. It is assumed that all oil exports are crude oil, thus not taking into account different levels of distilled fuels and gas. To simplify analysis, it is also assumed that all tanker traffic in the Strait of Hormuz and near the Gulf of Aden consists of crude oil tankers, and that the number of chemical tankers and other liquid tanker ships are negligible when compared to the total volume of tanker traffic in the region. The analysis assumed that only oil tankers of the Aframax size or above transit the Strait of Hormuz and the Arabian Sea, due to economies of scale. Lastly, the assumption is made that there will be no damage to the crude oil if the ship is successfully captured by pirates, and that the oil will still be capable of being processed and sold upon return of the ship.

B2. In order to translate the impact of piracy on the oil industry down to a company-level impact on one of the Big Six oil companies, we took ExxonMobil as a representative company. Given the estimate that ExxonMobil controls around 3% of the total revenue in the oil and energy industry, the assumption is made that 3% of the total financial impact from piracy will be representative of the financial risk of piracy for ExxonMobil.

Automobile Industry Assumptions

C1. For the automobile industry, it is assumed that Toyota car sales in the Middle East is representative of all other car sales in the region, and accounting for market share, the full value of the automobile industry in the Middle East can be found. All car sales are assumed to be

imported in whole car units (not locally manufactured or assembled from imported components), and sale prices are assumed to be on par with prices found on similar models in the United States. All revenues from car sales are assumed to go directly back to Toyota; revenue shares for local Toyota dealers are not taken into account.

C2. Cars are assumed to be transported via cargo ships (roll-on roll-off ships are counted as cargo ships for the purposes of this study), and it is assumed that roll-on roll-off ships can also have their capacity calculated in standard TEUs. The assumption is made that vehicles will retain their value even if the ship is successfully captured, and that the vehicles will be sellable on the open market at their original price even after ransom.

Food Industry Assumptions

D1. The food industry is more difficult to categorize than the previous two industries, due to the diversity of products that can be considered food. For the purposes of this analysis, import and export data for calendar year 2009 was collected for the Middle East, and any import categories that contained edible products, or products used in edible creations (such as palm oil and baking soda) were considered "food" categories. The sum of these categories across the six Middle Eastern nations mentioned above constitute the food imports and exports from which data was used for the analysis.

D2. Because of the varied nature of food products, it is difficult to determine an "average" price per ton of foodstuff. Thus, it is assumed that the price per ton of wheat is representative of all grain imports/exports, chicken is representative of all meat imports/exports, broccoli is representative of all vegetable imports/exports, palm oil is representative of all oil and baking goods imports/exports, and sugar is representative of all luxury food item imports/exports.

D3. Transportation wise, it is assumed that all food products are transported via bulk carriers, regardless of the food category. The need for refrigeration is assumed to have a negligible impact and would not require a different type of ship. Piracy attacks are assumed to cause no damage to food cargo; however, due to the relatively short shelf-life of most food products and their spoilable nature, food cargo is assumed to expire and go to waste if the ship is successfully captured (Ships are normally held for a number of months before ransom negotiations can be completed and the ship returned to the owners). Thus, all possible revenue from the cargo is assumed to be lost in the case of a successful pirate hijacking.

Research Methodology

Of particular assistance to this paper is the research methodologies used in the analysis of economic data presented in previous research. Though the majority of methods used in the analysis have been developed independently using information gleaned from publically available sources, some research methodologies have been based on those from previously published research.

Research methodologies were primarily determined based on the information that was available. Depending on the type of available information, different methods were used in order to convert the existing data to volume and monetary figures. However, in all cases, the starting point of the analysis is based on the calculated monetary value of all imports and exports of the industry, specific to the Middle East region. In the case of the oil and automobile industries, the monetary value of imports and exports was estimated by taking the annual volume of trade and multiplying by an estimated value per unit (barrel or vehicle, respectively) to arrive at the annual value of cargo imported/exported. In the case of the food industry, the monetary value is arrived

at directly by tallying historic trade information and extrapolating the data to model current day values. Volume information was then found by dividing the value of annual imports and exports by an estimated value per ton of foodstuffs.

After determining the value of total annual imports and exports to the region, piracy risk is calculated by filtering historic piracy statistics by ship type, incident frequency, and ship capture or hijacking frequency. This data is then translated into a piracy risk probability, expressed as a percentage, which essentially represents the long term expected average of piracy for each ship type. This percentage is then applied to the volume of total imports and exports per industry, and from there, applying the monetary value of cargo per each shipment captured determined the monetary impact of piracy on the industry. Additional analysis on the expected incident frequency per company, standard deviation of hijackings/incidents, and end financial impact (absolute loss vs. supply chain disruption/delay) is conducted as well to explore all distinct possibilities.

Detailed examples of the methodology and calculations used in calculating the estimated monetary impact of piracy on each industry is given below:

Piracy Cost Estimate: Oil Industry

To find the bottom line financial impact of piracy on the oil industry, the first step was to verify the average industry revenue, from which the proportional cost of piracy can then be determined. The estimated annual total exported production of crude oil from the Middle East in 2009 numbered 6,434,220,000 barrels, of which it is assumed 90% is exported via maritime transportation, or 5,790,798,000 barrels. A comparison with historical data shows that this

assumption is close to the actual figures, with actual 2009 maritime oil exports numbering 5,657,500,000 barrels (*Appendix: Table 5*).

Maritime oil export growth from the Middle East has been growing between 500 thousand to 1 million barrels a day each year. Assuming this trend holds true for 2012, daily oil volume transiting the Strait of Hormuz will number 18 million barrels a day, which translates to 6,570,000,000 barrels a year. This figure was then multiplied by the average crude oil commodity price of $87.04 to obtain the total value of the annual oil exports from the region.

*6,570,000,000 barrels * $87.04 per barrel = $571,852,800,000*

The volume of maritime oil exports in barrels was then divided by the average capacity per oil tanker to determine the number of oil tanker trips needed to ship total maritime oil exports.

Average oil tanker capacity = 1,242,198 barrels

(see Appendix: Table 6 for detailed capacity calculations)

6,570,000,000 barrels / 1,242,198 barrels per tanker trip = 5,289 trips.

By taking the average of piracy statistics from previous years, the average probability of a pirate attack and the probability of a successful capture were applied to the number of oil tankers needed to give the estimated number of tankers attacked and the number captured for 2012, respectively.

Probability of pirate incident = 0.712%

Probability of pirate attack = 0.153%

(see Appendix: Exhibit 1 for detailed probability calculations)

*5,289 tanker trips in region * 0.712% = 38 tankers attacked* [approximation]

*5,289 tanker trips in region *0.153% = 8 tankers captured* [approximation]

Multiplying the number of tankers captured by the average tanker capacity in barrels will give the volume of crude oil captured.

*8.1 tankers * 1,242,198 barrels/tanker = 10,065,934 barrels*

Multiplying the product with the price per barrel will result in the total value of crude oil captured on an average, annual basis.

*10,065,934 barrels * $87.04 per barrel = $876,138,901*

To translate this financial impact on the industry to a company-specific impact, the resulting value of crude oil captured was applied proportionally to the percentage of the industry revenue that ExxonMobil represented.

*$876,138,901 * .03= $26,284,167*

By applying a weight of 3% (proportional to ExxonMobil's share of the global oil industry), a figure of roughly $26.3mm was arrived at as being tied up in captured oil tankers due to piracy.

Summary 1: Results of Cost Calculations for Oil Industry

Number of expected hijackings	Value of cargo per ship	Estimated Cost (Industry)	Estimated Cost (Company)
8.1	$108,120,923	$876,138,901	$26,284,167

Piracy Cost Estimate: Automobile Industry

For the automobile industry, due to the nature of published information on car sales, it was easier to collect data and analyze data from a company-specific point of view. Toyota was chosen as an example of the automobile industry, and the analysis was conducted from a company level from the start.

Annual Toyota sales in the Middle Eastern region were determined based on year-end 2011 sales figures (Appendix: Table 7). A hypothetical "typical" Toyota car price was found by taking the weighted average of the prices of the best selling vehicles (Appendix: Table 8).

Toyota Sales – Middle East: 357,862 units

Average Price per unit: $27,700

This typical car price was then applied to the total sales to determine Toyota's annual revenue from the region. (Appendix: Table 9)

*Toyota Regional Revenue = 357,862 units * $27,700 per unit = $9,912,776,214*

To determine the number of container ships necessary for exports to the Middle East, an average container ship size was determined based on the simple average of existing container ship size classes in TEUs (Appendix: Table 10).

Average Container ship size = 6500 TEU

It was assumed that only 5% of the capacity of any cargo ship would be dedicated to shipping cars, and that each TEU would house, on average, 1.6 cars. This figure was reached by estimating the number of cars that can fit in each TEU. Depending on the size of the car and the use of suspension equipment, anywhere from 2 to 4 cars can fit in one 40-ft container (2 TEU units). Multiplying the number of cars per TEU by the number of containers on each container ship dedicated to shipping cars results in 520 cars shipped on average per container ship

*1.6 cars per TEU * (.05*6500 TEU per ship) = 520 cars per ship*

Dividing the number of cars sold in the region by the number of cars per ship results in the number of container ships needed.

357,862 units sold / 520 cars per ship = 688 ships.

This figure represents the estimated number of ships needed to ship the total amount of vehicles sold by Toyota in the Middle East region in one year (Appendix: Exhibit 2)

To accurately reflect the variety of cargo shipping in the region, and account for the number of cargo ships not containing any Toyota vehicles, the historical piracy statistics are first found from calculating the percentage of piracy attacks on container ships to the total annual volume of container shipping traversing the Strait of Hormuz. (Appendix: Exhibit 2 & Table 2)

Annual container traffic = 4883 ships

Average attacks per year = 56 ships

Average ships captured = 13 ships

Attack % = 56 / 4883 = 1.15%

Capture % = 13 / 4883 = 0.26%

To determine the number of ships likely to be captured required a simple multiplication of the cargo ship capture probability with the number of car-carrying cargo ships. Multiplying the product from that operation with the number of cars onboard each container ship will determine the number of cars captured.

*688 ships per year * 1.146% attack probability = 8 ships attacked per year* [approximation]

*688 ships per year * 0.261% capture probability = 2 ships captured per year* [approximation]

*Number of cars captured = 520 cars per ship * 2 ships = 1,040 cars*

Lastly, multiplying the number of cars captured by the average cost per car will give the amount of potential Toyota revenue captured each year by pirates (Appendix: Exhibit 2)

*1,040 cars * $27,700 per car = $28,808,000*

The total automobile industry impact of piracy is found by retroactively dividing Toyota's captured car revenue by its market share in the region.

Toyota Market % = 31.55% (Appendix: Insert 1)

$28,808,000 / 31.55% = $91,309,033

Average automobile container traffic = 688 ships/31.55% market share = 2181 ships

*2181 ships per year * 1.146% attack probability = 25 ships attacked per year* [approximation]

*2181 ships per year * 0.261% capture probability = 6 ships captured per year* [approximation]

The estimated effect of piracy on the automobile industry as a whole, in the Middle East region, is approximately $91.3mm tied up in captured container ships.

Summary 2: Results of Cost Calculation for Automobile Industry

Number of expected hijackings	Value of cargo per ship	Estimated Cost (Industry)	Estimated Cost (Company)
6	$14,404,000	$91,309,033	$28,808,000

Piracy Cost Estimate: Food Industry

The method of determining the total value of food imports and exports in the Middle East was a bit more complicated than for the previous two industries, due largely in part to the diffused nature of the food industry and of the various categories within it. The value of exports and imports of all edible categories was added together to account for the total value of food shipments. (Appendix: Table 11)

Although some of the exported food is undoubtedly re-exports of previous imports, for the purposes of this analysis, it is assumed that re-exporting would expose the cargo to piracy risk twice.

Value of 2009 food imports to the Middle East = $27.8 billion

Value of 2009 food exports from Middle East = $4.0 billion

Total value of food shipments = $31.8 billion

After obtaining the value of the total food exports and imports from the region, the figure in USD is translated to DWT by applying an "average" cost per ton of food. To find the average cost per ton, each of the main food categories were represented by one subcategory (for example, grains were represented by wheat). By finding the market value per ton of each subcategory, the weighted average of all five food categories was calculated to be, on average, $554.11 per ton. (Appendix: Table 12)

The total value of food imports and exports was divided by this conversion factor to arrive at the annual DWT.

Average price per ton of "food" = $554.11

$31.8 billion / $554.11 = 57,424,924 DWT

The average capacity of bulk carriers was determined on a DWT basis, similar to the process used for the determination of the average size of container ships and oil tankers, by taking the weighted average of bulk carrier sizes based on the percentage of traffic each ship size represented (Appendix: Table 13). Taking the annual DWT for food and dividing by the average ship capacity gave the number of voyages needed annually.

Average bulk carrier capacity (in DWT) = 72,750 DWT

Annual DWT of food shipments = 57,424,924 DWT

57,424,924 DWT / 72,750 DWT per ship = 789 ships ^{approximation}

Applying the piracy statistics for bulk carriers then determined the long-term expected number of bulk carriers captured each year. (Appendix: Exhibit 3)

Bulk carrier attack probability = 1.59%

Bulk carrier capture probability = 0.312%

Number of food-carrying bulk carriers = 789 ships per year

*789 ships * 1.59 % attack probability = 13 ships*^{approximation}

*789 ships *0.312% attack probability = 3 ship*^{approximation}

With the value of the cargo set at the capacity of the bulk carrier in DWT, multiplying the capacity by the food value conversion factor gives the total industry value of food that is attacked and captured. (Appendix: Exhibit 3)

*13 ships * 72,750DWT * $554.11per DWT = $507,447,503.88*

*3 ship * 72,750DWT * $554.11per DWT = $99,209,802.73*

The food industry is made up of a wide range of products, from grains and unprocessed meats to packaged and canned foods. Thus, it is difficult to categorize the absolute size of the food industry. To most accurately reflect the realities of food imports and exports to the Middle East, the packaged and processed food industry was taken as the basis for a relative size comparison. This was due to the ease of transport of packaged and processed foods, as well as the availability of accurate industry data.

The packaged food industry was estimated by the USDA to be worth approximately $4 trillion in annual sales (Global Food Markets, 2012). Considering Nestlé had annual revenues of approximately $119 billion USD in 2010, their revenue would account for about 3% of food industry sales worldwide. Taking this percentage and applying it to the value of food products attacked and captured by pirates calculated in Exhibit 3 gives the approximate value of Nestlé revenues lost due to piracy. (Appendix: Exhibit 4)

*Value of food attacked – Nestlé = $507,447,503.88 * .03 = $15,140,964.90*

*Value of food captured – Nestlé = $99,209,802.73 * .03 = $2,960,172.49*

The estimated effect of piracy on the annual revenues of Nestlé amount to approximately $2.96 million dollars lost each year due to food spoilage on captured ships.

Summary 3: Results of Cost Calculation for Food Industry

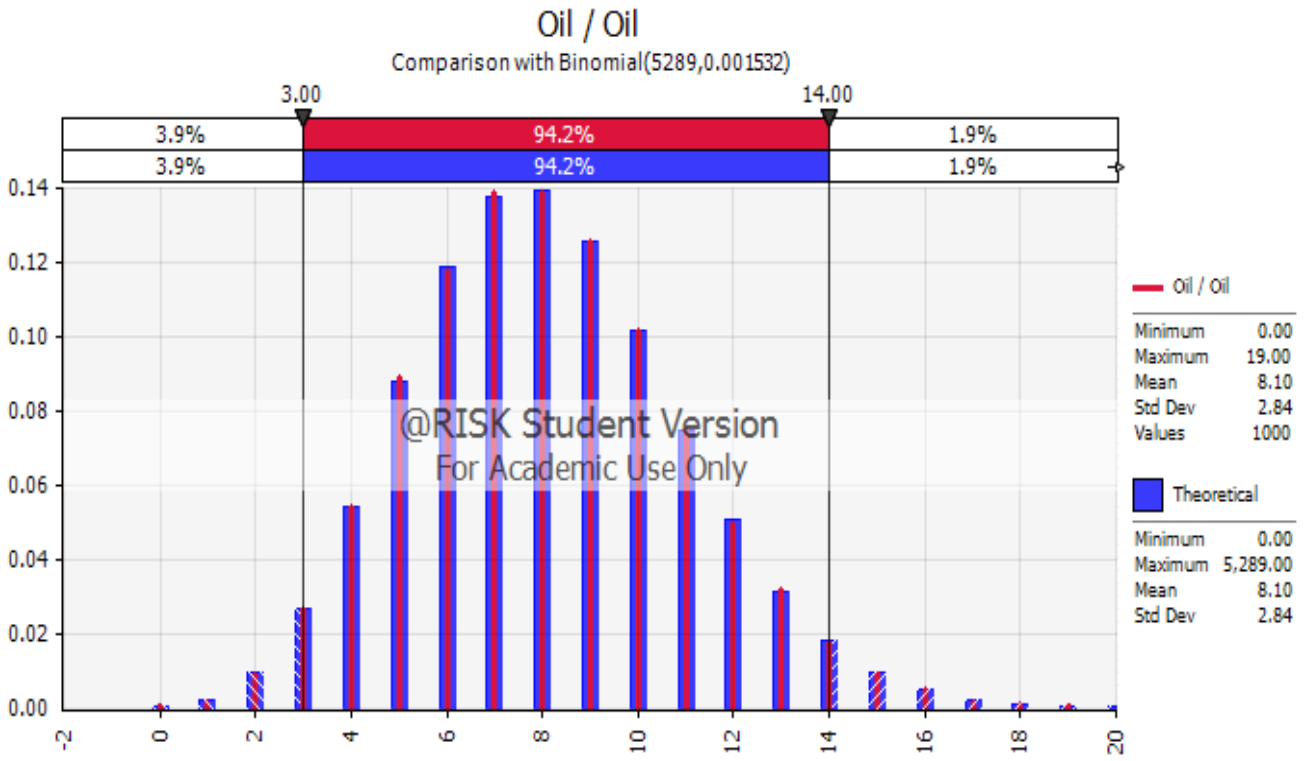
Number of expected hijackings	Value of cargo per ship	Estimated Cost (Industry)	Estimated Cost (Company)
2.5	$40,311,684	$99,209,802.73	$2,960,172.49

Analysis

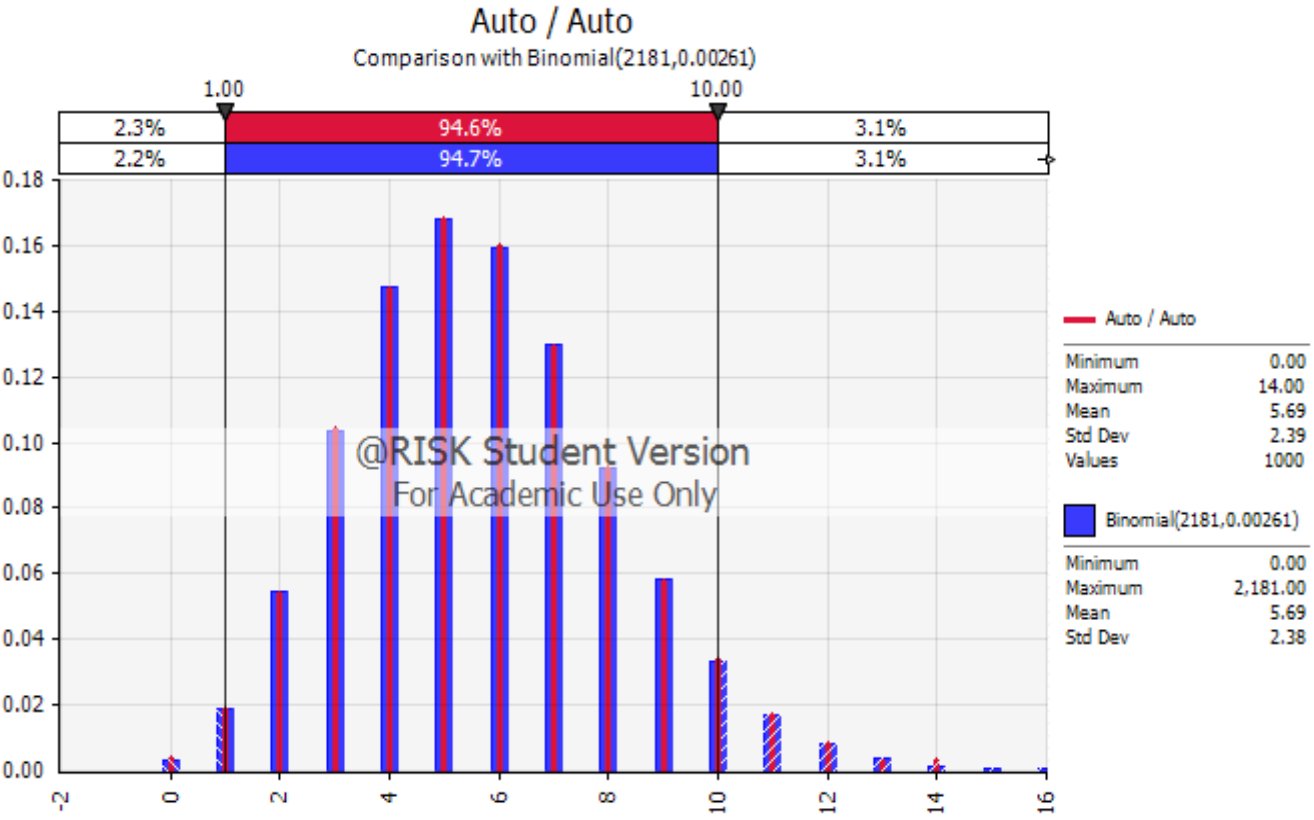
After completing the cost calculations per industry and company level, the average expected costs of piracy can be listed for each. However, these average figures, though indicative of the long term expected outcome, give no indication as to the range or variability of the risk. As a successful pirate hijacking is a rare occurrence, the addition or subtraction of one hijacking annually can have quite a large impact on the industry costs. Thus, an analysis is conducted on the range of piracy costs for each industry, using the standard deviation of piracy rates per ship type, to determine a confidence interval within which piracy costs can reasonably be expected to fall.

Using piracy data from the past four years, the standard deviations of the pirate hijack rates for each ship type were determined. Mapping out a normal distribution with the mean as the average number of ships captured annually that was determined in the previous section showed the distribution of possible hijackings within a certain confidence interval. In order to keep the figures manageable and in integer form to conform to real world expectations (it would be unreasonable to expect the capture of a fraction of a cargo ship), the confidence intervals were chosen to be around 95%. The results are shown in graphs 1 through 3 below:

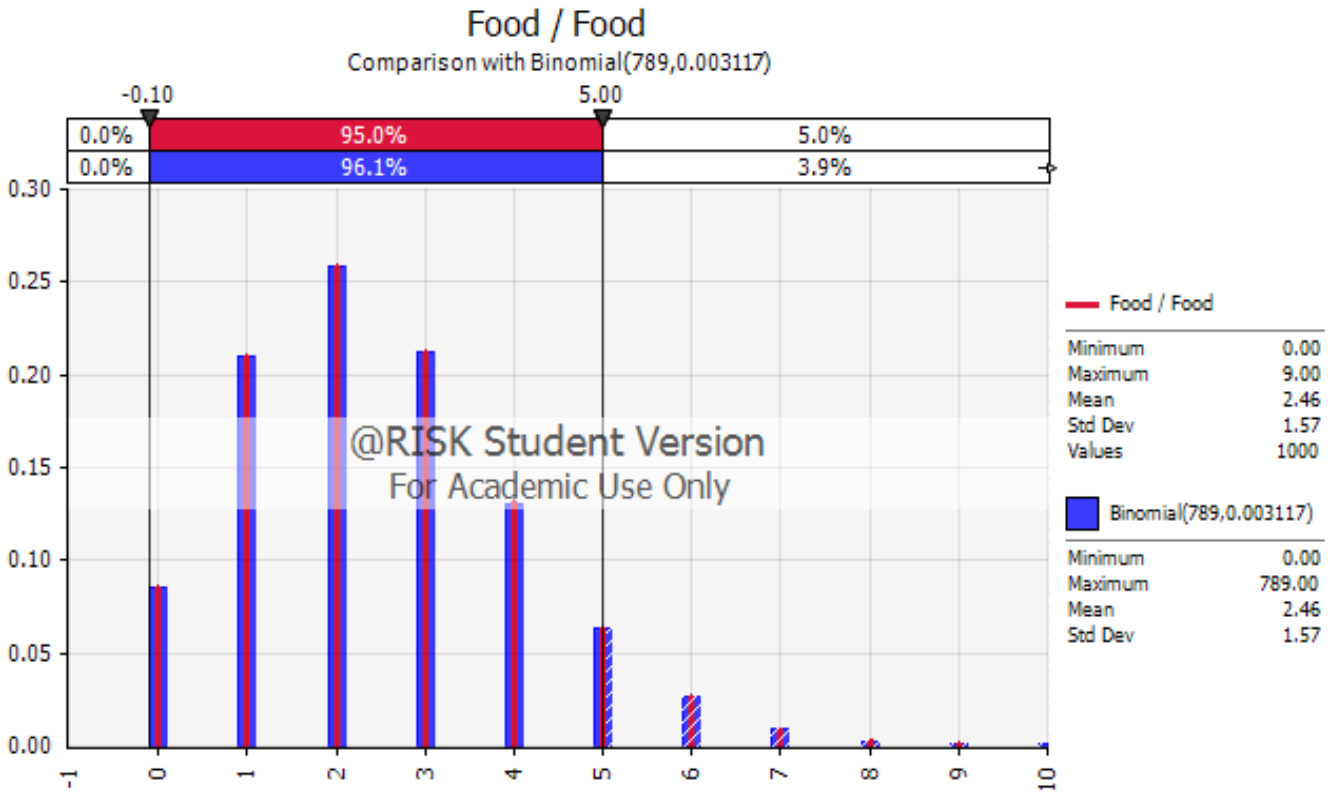
Graph 1 – Confidence Interval of ship capture for Oil industry



Graph 2 – Confidence Interval of ship capture for Automobile industry



Graph 3- Confidence Interval of ship capture for Food industry



After obtaining the upper and lower bounds from the confidence intervals, applying the dollar value per shipment gives the expected upper and lower range of piracy costs to each industry at a roughly 95% confidence interval. The results are shown below:

Exhibit 5: Range of expected piracy costs per industry

Mean	Lower bound	Upper bound	Confidence Interval	Value per shipment	Lower bound value	Upper bound value
Oil	3	14	94%	$108,120,923	$324,362,768	$1,513,692,917
Auto*	1	10	95%	$14,404,000	$14,404,000	$144,040,000
Food	0	5	95%	$40,311,684	$0	$201,558,422

**Upper and Lower bound figures were calculated taking into account the percentage of total container ships that carry automobiles.*

Analysis of the comparative costs of piracy for each industry in the broader macroeconomic context is done by taking the calculated cost of piracy per industry and dividing it by $6.6 billion, which represents the average macroeconomic cost of piracy (The Economics of

Piracy, 2011) to obtain a percentage value. This value represents the percentage of all piracy costs that this industry incurs.

Exhibit 6: Industry specific costs as percentage of macroeconomic costs

Industry	Expected Piracy Cost	% of Macroeconomic Cost
Oil	$876,138,901	13.3%
Auto	$91,309,033	1.4%
Food	$99,209,802	1.5%

Lastly, some additional analysis is done to calculate the percentage of all hijackings that each ship type makes up, and the probability of a successful pirate hijacking, given that an attack has occurred. With the historical piracy data on hand, dividing the number of each type of ship hijacked by the total number of reported ships captured will give the percentage of hijackings for that ship type. Dividing the successful ship captures by the number of incidents per ship type will give the percentage of cargo ships captured after coming under attack. These figures are indicative for later analysis, as the percentage of total hijackings when compared to the % of regional traffic each ship type comprises can reveal if disparities exist in anti-piracy preparedness across ship categories. Furthermore, high percentages of successful captures per pirate attack could indicate weakness in the ship design or inadequate security features that enable it to be captured more easily than other types.

Exhibit 7: Percentage of total hijackings by ship type &

Probability of successful hijacking after attack

Ship Type	% of Annual Traffic	% of total Hijackings	Successful Hijacking/Incidents
Tanker	32%	20%	22%
Container	29%	29%	23%
Bulk	39%	51%	20%

Chapter 4: Discussion of Analysis and Implications

Findings & Monetary Impact

From the figures presented in the above section, it can be seen that maritime piracy in and around the Strait of Hormuz has the highest nominal impact on the Oil industry, with a total of $876 million dollars worth of crude oil tied up in captured oil tankers. The Food industry ranks second in terms of the nominal impact of piracy, suffering $99 million dollars worth of costs in lost food cargo. Lastly, the Automobile industry is impacted the least by piracy, with $91 million dollars worth of vehicles tied up in captured containers ships and ro-ro ships.

When these numbers are compared with the industry size, the Oil industry is shown to be disproportionately affected by piracy activity. Approximately 0.03% of worldwide crude oil revenues are tied up due to piracy in the Middle East region. For the Automobile industry, this percentage is approximately 0.004%, and for the Food industry, it is only 0.002%. These statistics seem to lend credence to the perception that pirates tend to seek out high value targets such as oil tankers and container ships as opposed to lower value targets, such as bulk carriers.

Finally, the analysis shows that the size of the industry itself, along with a company's market share in that industry, determine to a large extent the impact that piracy has on their operations. Although ExxonMobil has the largest gross revenue of the three companies chosen for comparison and is in the industry most affected by piracy, it only makes up 3% of the global market for crude oil. Thus, ExxonMobil can expect to see approximately $26 million dollars in captured oil shipments, a relatively minor figure given their annual revenue and total industry losses. On the other hand, Toyota Motors has the most to lose from continued pirate activity, with an estimated $28 million dollars tied up in captured shipments. Despite the effect of piracy on the Automobile industry being almost ten times less than that on the Oil industry, Toyota's

11% global market share and high volume of vehicle sales in the Middle East expose it to more risk on a relative basis. Nestlé, being in a fragmented industry that sees few losses due to piracy and only making up 3% of industry sales, has the least to worry about when it comes to pirate activity. Expected losses for Nestlé amount to only $2.9 million dollars annually.

Implications

A number of financial and operational implications are raised by these findings. Most importantly, the expected monetary impact of piracy on annual revenues shows that efforts to increase the security of the supply chain may prove to be worth the investment, as long as the quantity invested in security features does not surpass the expected loss savings.

Piracy Variability

Although the figures presented in this analysis are long-term expected values of piracy, losses accrued by the industry and by the company may vary greatly from year to year. The oil industry is exposed to the most volatile risk, as the hijacking of oil tankers is a rare occurrence when compared to other ship types (making up only about 20% of successful ship captures), with a mean of 8 ships captured each year. However, the successful capture of one oil tanker by pirates can raise costs by over $100 million. With a historical standard deviation of 3.5 ships captured by pirates every year, the oil industry can expect an oil tanker hijack count of between 3 and 14 ships 94% of the time. (See Graph 1 above). Thus, at a 94% confidence interval, the Oil industry faces a range in the value of crude oil tied up by piracy between $324 million and $1,513 million, a span of $1,189 million. This standard deviation, coupled with the high cargo value of each ship, makes potential piracy losses in the oil industry very difficult to pinpoint.

Conversely, the Automobile industry faces relatively stable risk. The hijacking of container ships makes up approximately 29% of all ships captured by pirates, averaging

approximately 6 ships captured each year. For a 95% confidence interval, a range of ships captured is established to be between 1 and 10 ships per year. The revenue in cars present on each container ship is estimated at $14 million dollars; thus, the range in value lost due to piracy for the Automobile industry is between $14 and $144 million, a span of $130 million dollars.

The Food industry faces a much more variable cost of piracy throughout the year, although the variability is on par with that of the Automobile industry when accounting for the size of the Food industry. Although the food industry has a low average ship capture rate of about 3 ships per year and benefits from a low standard deviation of 2.3 ships average piracy capture rate, the value of individual shipments is much higher, at $40 million a shipment. Thus, the 95% confidence interval of food bulk carriers gives a range of 0 to 5 ships a year. This results in a range of losses due to pirate activity between $0 and $201 million dollars. These numerical comparisons show that the piracy impact on industries can vary greatly by year, the widest range of which exists in the oil industry, with volatility being less with the food industry and the most stable in the automobile industry.

Macroeconomic Share of Piracy

Macroeconomic costs of piracy were assumed to be in the range of $4.9 to $8.3 billion dollars a year. Evaluating the expected piracy costs per industry with the average macroeconomic cost of $6.6 billion reveals that the oil industry bears approximately 13% of the total economic cost of piracy. The food industry bears a smaller chunk, at 1.5%, and the automobile industry bears 1.4% of the costs of piracy. This lends credence to the recent moves by companies in the oil industry to reroute their oil tanker fleets, as the piracy cost to the oil industry is not only large in nominal figures, but also makes up for quite a large percentage of worldwide economic losses due to piracy.

When it comes to ship capture percentages and piracy rates as a percentage of regional traffic, it can be determined from Exhibit 6 in Chapter 3 that bulk carriers make up the most highly targeted vessels. This is most likely because of the high volume of bulk carrier shipments in the region. Additionally, the comparison reveals that bulk carriers face the highest risk of piracy on an absolute level. Conversely, oil tankers face the lowest absolute piracy risk, despite a number of well documented cases of oil tanker hijackings. This is in contrast to the perceived notion that oil tankers are subject to higher levels of absolute risk due to the valuable nature of their cargo. Container ships are proportionally represented in the percentage of cargo ship hijackings relative to the percentage of maritime traffic they make up.

Comparing the ratio of successful hijackings to pirate attacks reported for each ship category revealed comparatively little material for the purposes of this analysis. Besides indicating that bulk carriers are slightly more difficult to capture (or possibly less worthwhile from a pirate viewpoint), the analysis gives little indication of any ship type being significantly more difficult or easier to capture than another.

Product Considerations

Although the assumptions established in Chapter 3 are there to facilitate the calculation of estimated piracy costs, some of the implications raised by the findings support the challenging of those same assumptions. One of those implications to consider in this analysis is the nature of the product, and absolute product 'lost' as opposed to product 'tied up'. The differentiating factor between the two categories is that, while product 'lost' is considered to be of no value after the release of the cargo ship, product 'tied up' still retains revenue value after release. In this analysis, food products can be categorized as 'lost' product in the case of a successful ship capture, as any food products held for a significant period of time in uncertain environmental

conditions cannot reasonably be expected to sell to consumers. On the other hand, crude oil retains the same intrinsic value regardless of the length of time it has been tied up in captivity, and upon release, can still be processed into various grades of fuel. Automobiles straddle the spectrum in the sense that cars will retain some value regardless of the length of time it is tied up in captured cargo ships, however the relative value of the vehicle will decrease with time as newer models are introduced to the market and as environmental deterioration takes its toll. In this sense, there is some absolute value 'lost' for the automobile industry when vehicles are captured by pirates, however they will still retain some value and be sellable at a reduced price. When all these factors are taken into account, it is reasonable to assume that the food industry has the most absolute value 'lost' due to piracy, whereas the automobile industry loses some value in its products, but can still regain a portion of the original vehicle price. The Oil industry is the best inoculated to the loss of value of their cargo; for all intents and purposes, crude oil tied up in captured tankers acts as extra inventory in transit, which, upon release, can be converted into finished goods and bring in the same amount of revenue as before (assuming oil prices do not fluctuate significantly).

Lastly, one must consider the possibility of pirates making use of the captured cargo themselves. Crude oil is insulated against this risk, once again, due to the inability of pirates to make use of crude oil or to refine it into a usable form. When it comes to food products, there is a distinct possibility of pirates availing themselves of the cargo and consuming the goods. This could pose a risk for food companies, who stand to lose a significant portion of their cargo to pirate consumption. For automobiles, pirates are also capable of stealing or otherwise taking the vehicles for their own use. This situation is highly dependent on the ship type used to transport the vehicles (container ship vs. ro-ro ship), the loading/unloading equipment available to the

pirates, and their understanding of the ship controls. Container ships requiring the use of cargo cranes to unload cargo will likely prevent pirates from stealing any of the vehicles onboard, as pirates lack the infrastructure necessary to successfully unload the vehicles. In the case that the ship came equipped with its own cargo cranes, pirates will still lack the knowledge and training to utilize the unloading equipment. Ro-ro ships, however, pose a bigger risk, as pirates are capable of maneuvering the ship into a position where lowering the ramp will allow cars to be driven off the ship onto land. Although this is not a common occurrence, it is nonetheless possible given the affinity pirates have for lavish lifestyles.

In conclusion, the implication of the above findings indicate that companies must take into account a wide variety of factors when considering the proper response to piracy, and its impact on their operations. Although a company may have a large amount of revenue impacted by piracy, they must determine the relative size of this revenue when compared to their entire business. The standard deviation of piracy rates for each ship type, along with the range of possible revenues lost or tied up, should be factored into any attempt to quantify the risks associated with piracy for each company. Furthermore, companies must distinguish between whether or not this revenue impact will amount to an absolute loss, or purely a supply chain delay. These considerations must all be taken into account when deciding on investing in a risk mitigation strategy for piracy.

These considerations are only some of the many aspects for companies to take into account, however, as there are many more aspects of risk that have not been fully explored in this analysis. A discussion of the limitations of this analysis and areas for further exploration is given in Chapter 7 of this paper.

Insurance

Maritime insurance comprises a variety of policies, clauses, terms, and underwriting methods. For the purposes of this thesis, only the policies directly relatable to piracy are discussed in the following paragraphs.

Insurance for ships and cargo play a significant role in the larger context of maritime piracy. While the costs of piracy may be too great to bear for individual companies, insurance firms such as Lloyd's of London offer insurance clauses that often cover the bulk of the costs resulting from pirate activity. For carriers, these clauses are usually offered under war risk insurance, which covers damages to ships and equipment resulting from acts of war or combat, including piracy.

For shippers, a cargo insurance policy is generally issued as a companion to the war risk insurance policy. As a general rule, five major 'perils' are covered under most cargo insurance policies: Fire, Assailing Thieves, Jettison, Barratry, and All Other Like Perils (American Institute of Marine Underwriters, 2005). Cargo insurance can range from limited coverage of damages at a percentage of cargo value, to full damage coverage above a certain predetermined damage value (similar to deductibles in automobile insurance) to full coverage, depending on the specific clause employed. For the purposes of the below example, it is assumed that the shipper has employed an All-Risk policy, implying 100% coverage of any damages incurred by the cargo en route to its destination.

The premium of purchasing an insurance policy is generally accounted for based on a rating applied to each $100 value of goods insured. The rating is determined based on type of goods shipped, the route, as well as the destination port. An example insurance premium for an All-Risk policy for shipping vehicles from the United States to the Middle East would be

calculated at a rate of 1.3%. Applying this rating to the estimated vehicle shipment value found in the analysis of $14,404,000 (520 vehicles * $27,700 each), would result in an insurance premium of $187,252. Given that the average revenue impact from piracy for the automobile industry is only $41,872 ($91,309,033/2181), this insurance premium proves to be an unprofitable investment.

While the above is only meant as an example of the cost-benefit calculation one could complete when evaluating various insurance rates and premiums, the variety of different insurance policies, premium rates, and levels of coverage make a comprehensive analysis of various insurance policies and their end affect on the costs of piracy for a specific company difficult, not to mention futile in building a generalization from which conclusions can be drawn. Any attempt to evaluate the effect of insurance policies on the realized costs of piracy will need to be conducted on a case-by-case basis with a relatively narrow scope that is beyond the confines of this thesis. Suffice to say, the various aspects of maritime cargo insurance are multi-faceted and sufficiently customizable to fit the needs of a particular shipper in insulating them from piracy risk; however, the price of the insurance will need to be carefully balanced against the potential cost of piracy as explored in the *Findings & Monetary Impact* section above.

Chapter 5: Conclusion

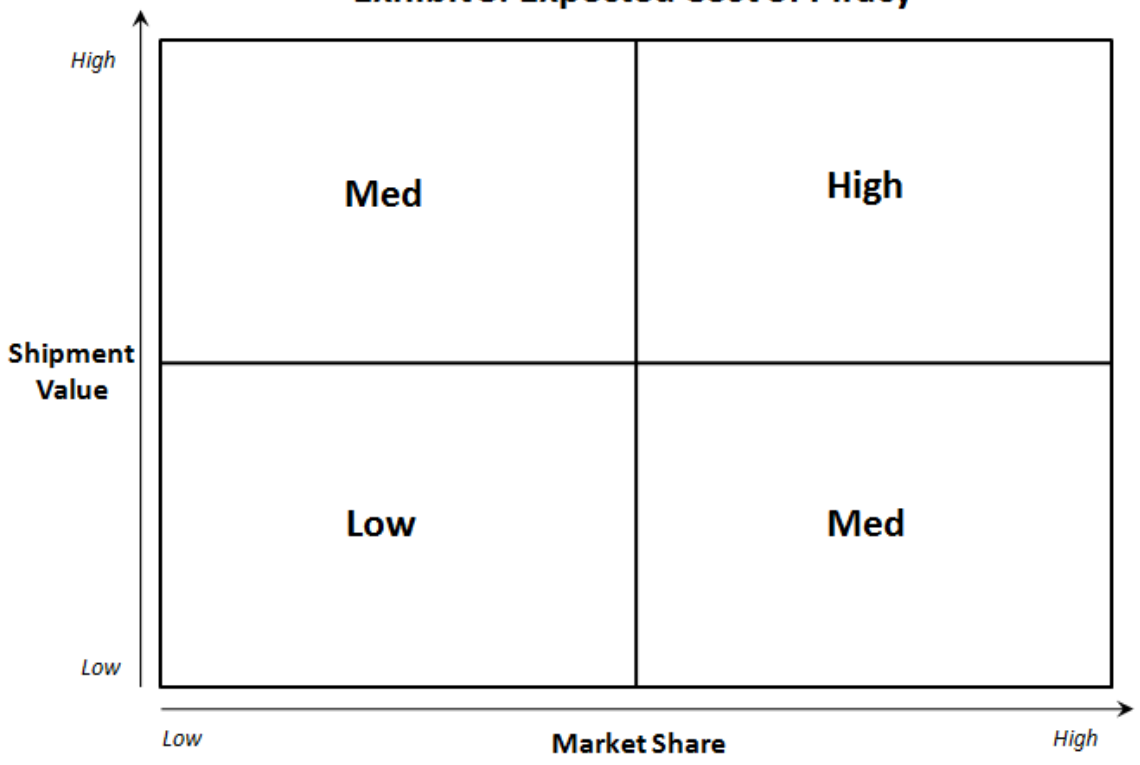
The findings from this analysis indicate that different industries are indeed affected to different extents by piracy. Although it is tempting to assume that all industries are affected proportionately to the volume of shipments sent through the region comprising the Strait of Hormuz and Arabian Sea, this analysis shows that this assumption does not hold true. Instead, industries with high value shipments are the most heavily affected by piracy. The total value of the shipment, as opposed to the individual value of one unit of product, was shown to be the primary driver of piracy costs for an industry. This trend reflects the tendency for pirates to target high-value shipments for infrequent attacks, rather than target low-value shipments frequently. Moreover, the relatively low number of successful pirate hijackings serve to raise the variability of piracy costs for firms with large shipment values, as a single standard deviation from the mean in the number of shipments hijacked can raise costs by hundreds of millions of dollars.

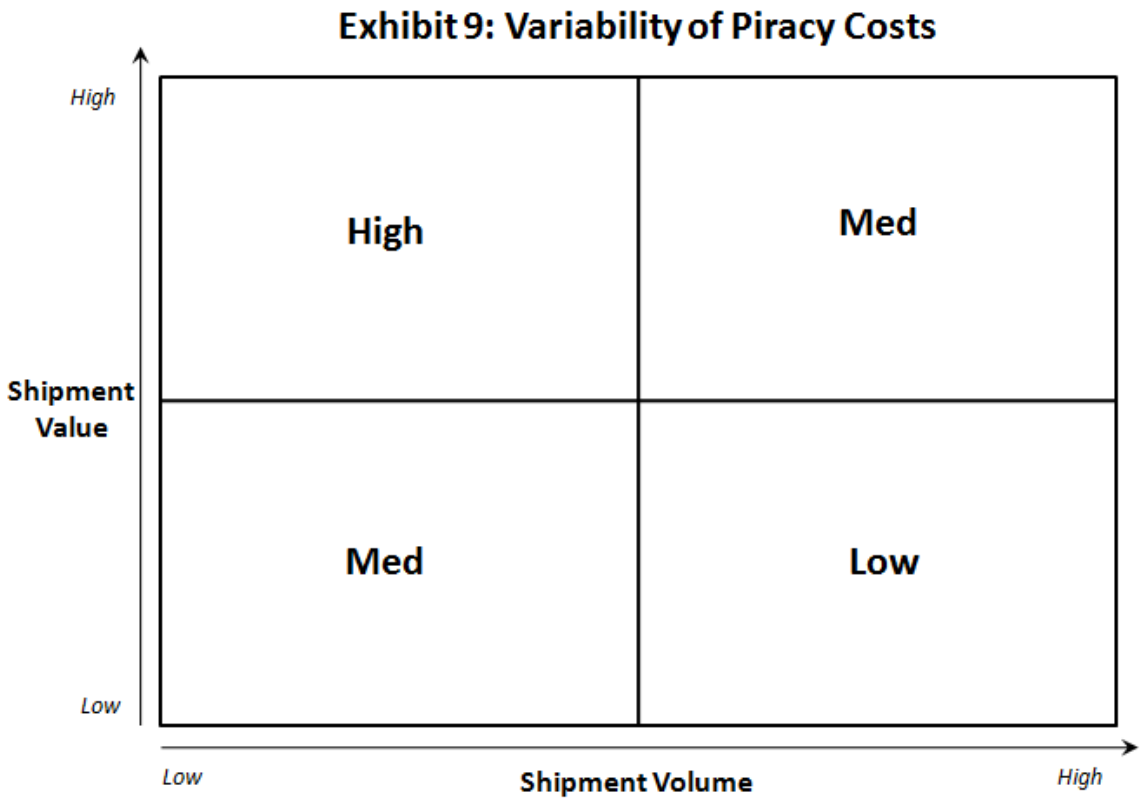
The extent to which a company is affected by piracy depends also on a number of other factors. Primarily, the factor to consider is the company's market share in the industry, and especially within the Middle East region. Companies with a large market share in the region can expect to see proportionately higher piracy costs than companies with lower market shares. Secondly, the product type and product attributes are important to consider. Firms with products that are subject to spoilage or market obsolescence have a higher cost of piracy than firms with perpetual products or in industries with relatively stable and unchanging product requirements. This is mainly due to product loss expected during the captivity period. Thirdly, the number of shipments needed for the company to transport its products determines the variability of piracy costs. This is related to the company's market share in the region, but the quantity of shipments

can be varied by increasing the capacity of ship sizes used or spreading out volume over a larger number of shipments. By decreasing the number of shipments, a company can reduce the possibility of a pirate attack, but correspondingly increases the variability of costs in case a pirate attack does occur. Increasing the number of shipments accomplishes the reverse, exposing the company to higher piracy risk, but reducing the variability of costs associated with piracy. Lastly, the company's annual revenue plays a part in the impact of pirate activity on the company's bottom line. Companies with smaller revenues may find piracy to be a veritable risk to their profitability, whereas larger companies may be able to weather piracy costs with little to no impact on their profitability.

The relationships stated above can be visually represented by the following exhibits:

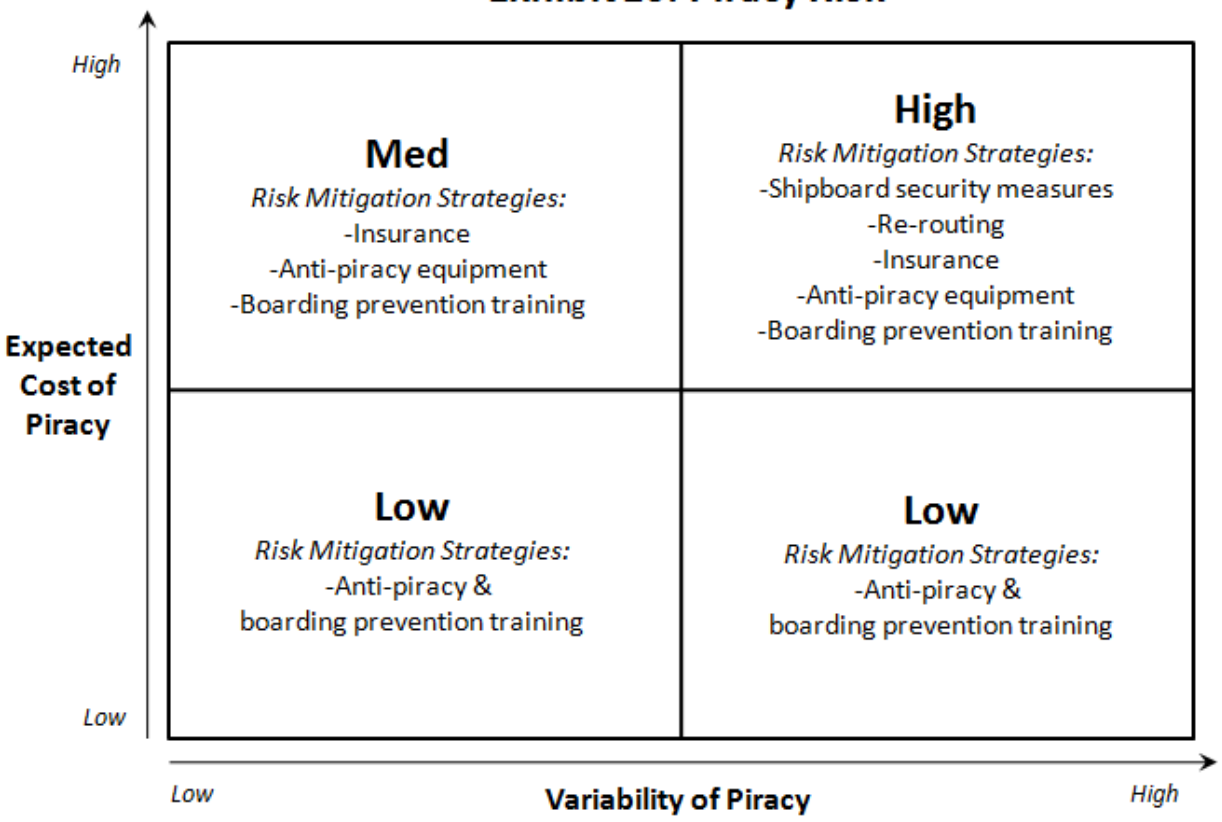
Exhibit 8: Expected Cost of Piracy





Furthermore, the interplay between the long term expected piracy costs and the variability of piracy costs gives rise to particular risk mitigation strategies that can be tailored to fit each situation. As companies move up in terms of their risk categorization, the risk mitigation strategies will need to increase as well in order to "layer up" different types of protection against piracy. Specific strategies are themselves more suited to a specific risk category than others. For example, changing the route of cargo ships is only reasonable given a low variability of piracy, which implies that changing the route will help decrease the potential piracy risk considerably. Similarly, employing extensive shipboard defensive measures such as barbed wire railings, sound guns, and security guards is only worthwhile in a high risk situation, where the decrease in variability and expected costs can be expected to surpass the investment required. Exhibit 9 shows piracy risk as it relates to the expected cost and variability of piracy, along with the recommended mitigation strategies.

Exhibit 10: Piracy Risk



In conclusion, industries and companies are affected to different extents by the ongoing piracy in and around the Arabian Sea and the Strait of Hormuz. Industries with a large number of shipments are usually exposed to the highest levels of pirate attacks, however, they do not necessarily incur the highest financial losses. High value shipments are generally subjected to higher piracy risk than lower valued shipments, and companies with large market shares and operations in the region may find the financial impact of piracy to be significant enough to warrant investing in mitigation strategies. Finally, the variability of piracy costs and the type of product shipped play important roles in determining the appropriate amount of attention and financial resources that should be deployed by a company to combat piracy.

Chapter 6: Limitations and Topics for Future Research

This section will seek to identify the limitations of this analysis, as well as topics and areas for future research:

This analysis on the impact of piracy was conducted with a very limited scope, and only explored three industries and companies out of many. Thus, the results of this analysis should only be considered in an academic context and should not be extrapolated to act as an overarching generalization for all industries and firms. Furthermore, the calculated figures given in the analysis and appendix are only approximations and estimates based on publicly available sources of information.

The oil industry cost calculations did not take into account the fact that, although ExxonMobil only accounts for 3% of the world's oil supply, they most likely account for a higher percentage of the crude oil exports from the Middle Eastern region. This is because many national oil conglomerates such as Petrobras and Gazprom primarily focus on developing local or neighboring oil deposits. Thus, their presence in the Middle East is considerably reduced. This would suggest that ExxonMobil in reality holds a larger percentage of the exports from the region than assumed. Thus, calculated costs for ExxonMobil were most likely lower than can realistically be expected. The automobile industry calculations assumed that all vehicles sold by Toyota within the six Middle Eastern nations were imported in that year. However, this assumption is highly unrealistic given the many land routes available for shipment from other parts of central Asia, and the existence of a large used car market. Thus, calculated costs for Toyota are most likely higher than can be expected. The food industry calculations assumed that any cargo captured by pirates will be lost due to spoilage. However, various food products are highly resistant to spoilage due to modern technologies such as vacuum packaging. Also, food

products stored in dry form are immune to most spoilage effects as well, with the exception of the effects of humidity. Nestlé makes a high proportion of spoilage resistant products, and thus the calculated costs are most likely higher than can be expected. In addition, given the type of products they make and the larger demand from Europe, Asia, and the Americas, it is most likely that Nestlé conducts a smaller percentage of business in the Middle East than the three percent market share they command worldwide.

This thesis did not explore many ancillary, but related, aspects of piracy and their impact on corporate profits and potential risk mitigation strategies. For example, the analysis did not fully account for the risk mitigation effect of various existing maritime insurance policies. The discussion on insurance was merely meant as a primer for future research and to make the reader aware of the potential effects of insurance in reducing piracy costs on a company-level. Not enough information was available to conduct a quantitative cost-benefit analysis of insurance policies. Existing piracy prevention and mitigation methods were not explored fully in this analysis, and were not evaluated for their costs vs. the expected savings from investing in the method. Possible damage to cargo due to unsuccessful pirate attacks was not taken into account for the financial analysis of piracy costs. Various aspects of the shipment routes (Eastbound vs. Westbound, traveling through the Gulf of Aden vs. around the Cape of Good Hope) were not taken into account in this analysis, as all routes were assumed to pose equal piracy risk. Realistically, shipments that traverse the area close to the west coast of Africa are subject to the most piracy risk. Additionally, attributes and qualities of various ship classes were not taken into account when calculating the potential piracy risk, as larger ships generally have a lower probability of being successfully hijacked due to their technological sophistication and sheer size. Seasonality in the supply and demand for certain products were not factored into the

calculation of piracy costs. As piracy is most rampant in the summer and spring seasons, it can be assumed that products shipped during that time are exposed to a higher level of piracy risk than can otherwise be expected.

Further research in this field should focus on the impact of insurance, and the considerations various insurance policies bring into play when responding to piracy. Investigation into the impact of piracy on other industries and companies would need to be completed before a comprehensive correlation graph can be drawn up regarding the relationship between shipment value, company size, market share, and piracy costs. Moreover, efforts should be made to verify estimated figures with credible sources to ensure accuracy. The best scenario would be to verify the calculated figures with the example companies themselves to gauge the degree to which this methodology successfully estimated the financial impact of piracy.

Future research can also be conducted into the financial impact of using different shipping routes, as well as different ship choices. The possibility for piracy risk to be reduced through a combination of safer shipping routes and more advanced ship design could be investigated. Proposals for mitigating piracy risk can be evaluated for their potential benefit, and compared against the estimated cost to determine the projected savings from implementing the anti-piracy measure. Lastly, the data set for piracy figures and statistics can be updated to include a longer period of time to better reflect trends in piracy and to better estimate average piracy levels and standard deviations.

Appendix

Table 1 – Historical Piracy Statistics

Year:	2008	
	Attacked	Captured
Total	111	42
Tanker	26*	19
Container	37*	14
Bulk/Other	48*	18

Year:	2009	
	Attacked	Captured
Total	217	47
Tanker	32*	7
Container	83*	18
Bulk/Other	102*	22

Year:	2010	
	Attacked	Captured
Total	223*	49
Tanker	55*	12
Container	68*	15
Bulk/Other	100*	22

Year:	2011	
	Attacked	Captured
Total	231	26
Tanker	36*	4
Container	36*	4
Bulk/Other	160*	18

**denotes estimated figure*

Note: All "Captured" figures are included in the "Attacked" figures. (ex: There were 111 pirate attacks in 2008, of which 42 resulted in successful ship hijacks)

Table 2 – Calculated Average Piracy Statistics

	Average Attacked	Average Captured
Total	186.33	41
Tanker	37	8.25
Container	56	12.75
Bulk/Other	102	20

Table 3 – Oil traffic statistics: Strait of Hormuz

2008	
Shipments/day	18
Flow/day	17000000
Annual shipments	6570
Attack %	0.004022614
Capture %	0.00152207

2010	
Shipments/day	14
Flow/day	16000000
Total shipments	5110
Attack %	0.010687328
Capture %	0.002348337

2009	
Shipments/day	13
Flow/day	15500000
Total shipments	4745
Attack %	0.006811201
Capture %	0.001475237

2011	
Shipments/day	14
Flow/day	17000000
Total shipments	5110
Attack %	0.006954689
Capture %	0.000782779

Note: Attack % and Capture % calculated using tanker figures from Table 2

Table 4 – Calculated Average Piracy Percentages: Oil

	Average
Attack %	0.007118958
Capture %	0.001532106

Table 5 – Oil production figures

Oil Exports by Country -2009 Estimates	**bbl/day**	**bbl/year**
Saudi Arabia	7,635,000	2,786,775,000
UAE	2,395,000	874,175,000
Iraq	1,910,000	697,150,000
Kuwait	2,127,000	776,355,000
Iran	2,523,000	920,895,000
Qatar	1,038,000	378,870,000
Total:	**17,628,000**	**6,434,220,000**
Maritime export total:		**5,790,798,000**
2012 Estimated maritime oil export:		**6,570,000,000**

Table 6 – Long Haul tanker data & capacity calculation

	Number	**Capacity (bbl)**	**Num*Capacity**
# of long haul crude oil tankers:	1222		
PanaMax	63	500,000	31,454,311
AfraMax	488	750,000	365,656,371
SuezMax	282	1,000,000	281,516,088
VLCC	384	2,000,000	767,485,199
ULCC	6	4,000,000	25,163,449
Average capacity (div by total)			***1,242,198***

Exhibit 1 – Estimated 2012 piracy calculation for Oil Industry

Tankers required	5289
Probability of incident	0.007118958
Probability of hijacking	0.001532106
Crude Oil Price(latest) per bbl	$87.04
Middle East Oil Revenue	$571,852,800,000
Number of tanker incidents (Est.)	37.65224994
Number of tankers hijacked (Est.)	8.103324311
Middle East oil revenue attacked	$4,070,996,003
Middle East oil revenue captured	$876,138,901
Exxon Mobile impact	$26,284,167.03

Table 7 – Toyota sales by model by country

SAUDI ARABIA	Sales	Mkt %
Hilux	44744	7.5
Camry	38940	6.6
Corolla	38708	6.5
Yaris	20992	3.5
Land Cruiser	14894	2.5
Fortuner	13275	2.2
Land Cruiser P/U	8719	1.5
Hiace	7514	1.3
Innova	6770	1.1
Prado	6486	1.1
Aurion	5665	1
Sequoia	5475	0.9
Avalon	5025	0.8
RAV4	4237	0.7
FJ Cruiser	4024	0.7
Dyna	1532	0.3
Coaster	1295	0.2
Sum Mkt %		38.4

UAE	Sales	Mkt %
Corolla	12288	5
Hilux	11416	4.7
Land Cruiser	11011	4.5

Camry	9261	3.8
Prado	9051	3.7
Yaris	6463	2.7
Hiace	3907	1.6
Fortuner	3745	1.5
Land Cruiser P/U	3738	1.5
FJ Cruiser	2308	0.9
RAV 4	1170	0.5
Coaster	1049	0.4
Innova	957	0.4
Avalon	837	0.3
Sequoia	661	0.3
Previa	587	0.2
Aurion	574	0.2
Sum Mkt %		32.2

QATAR	Sales	Mkt %
Land Cruiser	5955	9.6
Hilux	5079	8.1
Camry	1753	2.8
Corolla	1748	2.8
Prado	1497	2.4
Hiace	690	1.1
Coaster	455	0.7
FJ Cruiser	448	0.7
Land Cruiser P/U	361	0.6
Fortuner	353	0.6
Avalon	295	0.5
Sequoia	184	0.3
Sum Mkt %		30.2

KUWAIT	Sales	Mkt %
Prado	5720	5.1
Hilux	5551	4.9
Camry	4746	4.2
Corolla	3428	3
Land Cruiser	3167	2.8
Aurion	1974	1.8

Fortuner	906	0.8
Sequoia	601	0.5
Hiace	587	0.5
Yaris	568	0.5
Avalon	541	0.5
FJ Cruiser	477	0.4
Innova	420	0.4
Sum Mkt %		25.4

Note: Sales information unavailable for Iraq due to ongoing political and sectarian turmoil
Note: Sales information unavailable for Iran due to sales embargo and indigenous automobile production initiative

Insert 1 – Average Toyota Market Share in Middle East

AVERAGE MKT %	31.55%

Note: Average of above "Sum Mkt %"

Table 8 – Estimated average car value

CAR VALUES	**In USD**
Compact (Corolla)	$17,000
Sedan (Camry)	$25,000
Minivan (Sienna)	$32,000
SUV (Hilux)	$35,000
Ave car price weighted (.25, .25, .1, .4)	$27,700

Note: Prices taken from average retail prices of models on US market

Table 9 – Total Regional Toyota sales

Toyota car sales in Saudi Arabia (2011)	228295
Toyota car sales UAE	79023
Toyota car sales Qatar	18818
Toyota car sales Kuwait	28686
Est. car sales Iran	0*
Est. car sales Iraq	3040
Total Toyota sales:	357862
Total Toyota Revenue:	$9,912,776,214.44

**Iran sales estimated at 0 due to UN economic sanction & import embargo.*
Note: Toyota Revenue found by multiplying total sales with Ave car price from Table 8.

Table 10 – Average container ship size in TEUs

SIZE	CAPACITY (TEU)
ULCV	15000
New Panamax	12500
Post Panamax	8000
Panamax	4000
Feedermax	3000
Feeder	2000
Small Feeder	1000
Ave. ship size	**6500***

**Simple average*

Exhibit 2 – Estimated 2012 piracy calculation for Automobile Industry

# Container Ships	4883
Ave. container ship size	6500
cars/TEU	1.6
cars/ship (*5%)	520
Container ship trips in region	4883
Automobile ship trips	2181.28
Toyota ship trips	688
Incident %	0.01146
Hijack %	0.00261
# of auto ships incident	8
# of auto ships hijacked	2
Toyota revenue attacked	$115,232,000
Toyota revenue captured	$28,808,000
Automobile Industry revenue attacked	$365,236,133.12
Automobile Industry revenue captured	$91,309,033.28

Table 11 - 2009 Food imports in thousands of USD

Food Imports (in USD thousands)	**Import**	**Export**	**NET total (I+E)**
Saudi Arabia	8,961,859	934,665	9,896,524
UAE	7,755,293	1,841,101	9,596,394
Kuwait	1,732,691	160,721	1,893,412
Iran	5,047,120	1,012,206	6,059,326
Iraq	3,672,485	55,022	3,727,507
Qatar	644,195	2,510	646,705
Total	27,813,643	4,006,225	**31,819,868**

Table 12 – Average food price calculation

	Average Food Prices/ton	**Price (USD)**	**Weight**	**Price*Weight**
*based on wheat price Dec. '09	*Grains*	206.25	0.55	113.4375
*based on average chicken prices	*Meat*	2000	0.1	200
*based on average price of broccoli '09	*Vegetables*	833.35	0.2	166.67
*based on palm oil price Dec. '09	*Palm oil*	727.6	0.1	72.76
*based on sugar price Dec. '09	*Sugars*	24.9	0.05	1.245
	"Food"		1	**554.1125**

Table 13 – Average bulk carrier size

Bulk Carrier sizes	**DWT (metric ton)**	**Traffic**	**DWT * Traffic**
Handysize	25000	9%	2250
HandyMax	50000	9%	4500
PanaMax	70000	20%	14000
Capesize	80000	50%	40000
Very Large	100000	12%	12000
*Average size**	72750		

**Average size is sum of DWT*Traffic colum*

Exhibit 3 – Estimated 2012 piracy calculation for Food Industry

TOTAL Food Import + Export	
$USD	$31,819,868,000
Ave $/ton	$554.11
ave tons/yr	51,955,470
Ave size of bulk carrier	72750
Shipments required	789
Total tons shipped worldwide	2800000000
Total shipments worldwide	38488
Total shipments ME region*	6415
Incident % for bulk ships	0.015947505
hijack % for bulk ships	0.003117857
bulk carriers attacked	12.6
bulk carriers captured	2.5
Food value attacked	$507,447,503.88
Food value hijacked	$99,209,802.73

Exhibit 4 – Estimated 2012 piracy calculation for Nestlé

Food Industry Size	$4,000,000,000,000
Nestlé Revenue	$119,350,000,000
Market Share	2.98%
Food value attacked - Nestle	$15,140,964.90
Food value captured - Nestle	$2,960,172.49

Table 14 – Approximate industry size in revenues

Industry	**Revenues**
Oil	$2.6 Trillion
Automobile	$2.14 Trillion
Food	$4 Trillion

Insert 2 – Historical standard deviation of ships captured annually by industry

	Oil	**Auto**	**Food**
St. Dev.	3.5	6.1	2.3

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