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The price of modern maritime piracy

Inmaculada Martínez-Zarzoso*, Sami Bensassi**,

Abstract

A growing body of literature has recently focused on the economic origins and consequences of modern maritime piracy and on the perception that the international community has failed to control it. This paper aims to investigate maritime transport costs as one of the channels through which modern maritime piracy could have a major impact on the global economy. A transport-cost equation is estimated using a newly released dataset on maritime transport cost from the OECD together with data on maritime piracy from the IMB. Our results show that maritime piracy significantly increases trade cost between Europe and Asia.

Key words: maritime piracy, transport costs, maritime trade, panel data

JEL Classification: F51

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1- Introduction

There is growing evidence showing that maritime piracy increases maritime transport cost for a number of reasons. First, in 2008 some ship-owners have made clear their intention to re-route some of their lines to avoid dangerous waters. Second, the Gulf of Aden was added by Lloyds in its list of warzones in May 2008 based on the claim of insurers and sailors to demand a premium when a vessel navigates this region. Finally, firms providing security services or devices on board are burgeoning as a consequence of piracy [1]. Those are probably the main channels through which freight rates are impacted by maritime piracy. However, the lack of systematic data on insurance contracts[2], salaries paid by ship-owners, the proportion of ships re-routed, the investment in defense measures and poor data on freight rates made difficult to implement any comprehensive study of the impact of piracy on transport cost. This is an important caveat given that in a world of decreasing trade barriers related to custom duties and tariffs; transport cost have become one of the main obstacles to international trade (Hummels, 2001).

As piracy acts occurs mainly on the Euro-Asia maritime trade route, higher freight rates may hinder trade between these two continents. Increasing transport prices might also reinforce the idea, put forward by the shipping industry, to develop a north trade route between Europe and

[1] The most important shipping companies, CMA-CGM, MSC and Maersk have announced in 2009 they would divert some of their lines through the Cape route (Times 2008, Port Strategy 2009). The Indian shipping association has declared that depending upon the size, war risk premium for merchant vessels sailing in Indian Ocean has gone up from $500 per ship and per voyage to up to $150,000 per ship and per voyage (Financial Express, 2011). Shipping companies as Interoient Line Services have considered hiring private security service companies costing US$60000 per trip (Miller, 2008).

[2] See Ploch et al. (2010) for more information on the problems linked to insurance, notably the fact that US ship-owners do not have to insure themselves against the risk of war.

Asia passing through the Artic region. This development could have heavy consequences in terms of environmental costs and on the economies currently benefiting from their position on the current route between Europe and Asia as Egypt or Singapore.

This paper aims to fulfill some of the abovementioned gaps in the literature by testing the effect of modern maritime piracy on maritime trade cost. We propose a simple model of transport cost determination and derive a transport costs equation augmented with maritime piracy as an additional explanatory variable. To our knowledge, this is the first study that focuses on unitary transport costs as response variable. We overcome the major hurdle of data availability by using a new database on maritime transport cost developed by the Organization for Economic Cooperation and Development (OECD) and data on modern maritime piracy obtained from the International Maritime Bureau (IMB). The sectoral information provided in the maritime transport cost database allows us to test whether pirates attack more ships transporting certain type of goods[3].

Our findings show a significant and positive impact of maritime piracy on maritime transport cost. One additional ship hijacked results in 1.2% increase in maritime transport costs between Europe and Asia. These results maybe of importance for policy makers interested in the relative position of Euro-Asian trade compared to USA-Asian trade. In particular, we show that localized conflicts could harm selectively some international trade routes.

This paper is organized as follow: Section 2 reviews the literature on maritime piracy and transport cost. Section 3 describes the data and presents some descriptive statistics. Section 4

[3] Hasting (2009) reports anecdotal evidences suggesting that that may be the case in the Malacca Strait.

outlines the model specification and empirical estimation and section 5 presents the main results. Concluding remarks are presented in section 6.

2- MARITIME PIRACY AND TRANSPORT COST

Our paper brings together two different strands of the economic literature: whereas the first one analyzes the economic aspects of modern maritime piracy, the second focuses on the determinants of international transport cost.

2.1 Modern maritime piracy and international trade

A number of international trade economists have modeled the impact of adverse conditions, such as insecurity, conflicts and terrorism, on international trade (Anderson and Marcouiller, 2002 and 2005; Mirza and Verdier, 2008). Maritime piracy has also been specifically linked to trade. In particular, Bendal (2010) and Fu et al (2010) focus on the economic impact of maritime piracy on trade through the decision of ship operators to change their main trade routes between Europe and Asia in order to avoid Somali piracy. Moreover, Bensassi and Martinez-Zarzoso (2011) evaluate the impact of maritime piracy on the volume of trade between European and Asiatic countries. In this line of study we aim to extend this research by analyzing the effect of maritime piracy on the price of maritime transport.

We also contribute to the ongoing debate in the scientific community on the motivations and the methods used by pirates. Some scholars sustain that pirates are not choosing their prey according to the shipment transported by the vessel (Mejia and al, 2009), but tend to avoid attacking ships flying the colors of countries having military presence in their close vicinity (Kiourktsoglou and Coutroubis, 2010). Another view supported by Hastings (2009) is that pirates choose their targets according to the value on the black market of the shipment transported. He indicates that Somali and Malaccan pirates show a different behavior. Whereas Somali pirates are mostly interested in the expected ransom they will receive for the ship and the crew, Malaccan pirates are mostly interested in selling back rapidly their loots. The main reason for the latter behavior is the pressure put by the authorities around them and the possibilities that a particular region offers to sell back the lootings done. However, the fact that the Malaccan pirates care about the shipments of the vessels they attack does not mean that they will systematically prey on the same sort of merchandises. Our paper gives some support to the first argument, namely pirates are not concern with the type of good transported, by showing that at least within broadly defined goods categories this is not the case.

2.2 The determinants of transport cost

For many years international trade economists have been using the iceberg transport cost[4] formulation as an analytical devise that greatly simplify trade analysis. However, the explicit iceberg assumption is not observational or empirical. Indeed, in reality transport cost per tone is not invariant with respect to the tonnage of material deliver. In applied work, distance has been used for many years in gravity models of trade as a proxy for transport costs, assuming that transport cost is an increasing function of distance between the trading countries. However distance remains an unsatisfactory measure of trade cost because it is time unvaried and independent of the tonnage of transported goods. It has been only in the last two decades that more sophisticated ways have been used to measure transport cost and to analyze its impact on international trade. In the early 2000, Limao and Venables (2001) and Micco and Perez (2001)

[4] According to the iceberg transport cost assumption, part of the goods to be delivered are consumed by the very act of transporting.

added infrastructure variables to gravity equations to better characterize the impact of transport costs on trade. A second wave of research emphasized that transport costs is indeed endogenously determined (Martinez Zarzoso and Suarez Burguet, 2005; Martinez Zarzoso and Wilsmeier, 2007; Korinek and Sourdin, 2009ab). Transport cost may be endogenous for a number of reasons, such as the presence of economies of scale in transports or the existence of trade imbalances that causes the price of transport to differ according to the direction of trade. For example, Martinez Zarzoso and Suarez Burguet (2005) estimate a simultaneous system of equations of transport costs and trade where both variables are considered as endogenous. Similarly, Martinez Zarzoso and Wilmsmeier (2007) propose a transport costs model in which trade is endogenous and trade imbalances are an important determinant of transport cost. We specify a similar model in which modern maritime piracy is introduced as an additional variable that determines international maritime transport costs.

Finally, it is worth mentioning that it is outside the scope of the paper to investigate the channels through which piracy affects transport costs using statistical methods. As mentioned in the introduction we only found anecdotal evidence showing that sailors' salaries and insurance cost have increased as a consequence of maritime piracy. Indeed we did not find comprehensive data on neither insurance premia nor sailors' salaries. In addition, differences between the various types of insurances across countries made difficult any comparison. For example a federal program, the U.S Maritime War Risk Insurance Program covers for the additional risk of maritime piracy directed against U.S vessels (Ploch et al. 2010)

Concerning the use of the Cape Route it is particularly difficult to have a clear evaluation of the number of ships being effectively re-routed. It is hard to believe that the re-routing of the ships through the Cape may be a safe solution for most of the maritime commercial traffic as the activities of Somali pirates expanded to the north of Madagascar and Mauritius Island (see Figure 1). Finally, shipping companies are particularly secretive when it comes to the measures they used to defend their ships. For neither of these variables, we find satisfying proxies to be used in our study.

3 MARITIME PIRACY AND TRANSPORT COSTS: THE CURRENT SITUATION

3.1 Geography of maritime trade and piracy

The surfacing of maritime piracy depends on the existence of advantageous geographical conditions, namely narrow straits to spot future preys, islets or coastal areas remote enough to escape any form of authorities (Murphy, 2008; Ong-Webb, 2007). Not only geographical conditions are important, but also the geo-economic and political context of the countries suitably located to host piracy. Maritime piracy could indeed take roots when intensively used maritime trade routes pass in the vicinity of potential pirates' harbors located in failed or weak states. Nowadays, the two main maritime piracy hot spots, the Malacca straits and the Gulf of Aden, show these favorable conditions. The Malaccan piracy was more intense in the late nineties; whereas Somali piracy plays today the leading role. These two hot spots of maritime piracy are located on the trade routes linking Asia to Europe.

In order to examine the extent of the problem posed by piracy to shipping between Europe and Asia, we rely on a similar strategy as in Bensassi and Martinez-Zarzoso (2011), but we focus on the price of transport as the response variable instead of focusing on trade volumes. We have divided the oceans between the two continents into five regions: the European Seas (ES) from the coastal areas of Iceland and Norway in the North to the waters of the Canary Islands in the

South, in addition to the Mediterranean and Black Seas; the Red Sea and Gulf of Aden (RSGA) which includes a vast area of the Indian Ocean along the shores of Oman, Somalia and Tanzania; the Indian Sub-Continental Seas (ISCS) along the shores of Pakistan, India, Bangladesh, Ceylon and the Maldives; the South-East-Asian Seas (SEAS) comprising the waters of Indonesia and the Philippines, as well as those of Malaysia, Vietnam, Thailand, Myanmar and Cambodia; and the East-Asian Seas (EAS) which encompasses the Yellow Sea between China and Korea, the East and South China Seas, and the Japanese coasts .

Figure 1. Maritime Regions

A ship heading from a port in northern Europe to China must cross all five maritime regions; four if it ends its journey in Singapore and three if it unloads its shipment in Mumbai (see Table A.1 in the Appendix). The International Maritime Bureau (IMB) Live Piracy Report, offers information on the number of incidents of piracy occurring annually in each of the five regions between 1999 and 2007, as well as the number of incidents on three different routes linking Europe and Asia over this 9 years period (see Graph A.1 & A2 in the Appendix).

We are mostly interested in the Euro-Asia route because very few piracy incidents occur on the main shipping lines connecting other large economic areas. A way to investigate graphically the impact of piracy on transport cost is to compare the evolution of transport cost in the Europe-Asia route with the evolution in other regions without piracy. In this way we are able to compare with the counterfactual of almost no-piracy incidents. In Figure 2 we show the evolution of maritime transport costs between two trade routes: the USA-EU15 trade route and the China-EU15 trade route. Only the second route has been plagued with a high level of piracy. The figure indicates that the freight rates for container transport show a different evolution for each trade route. Whereas transport costs show a clear decreasing trend for the USA-EU15 trade, for the China-EU15 the numbers decrease only slightly over the whole period and show spikes in 1999 and 2004. The occurrence of these peeks could be due to maritime piracy, but market conditions may have played also an important role. In our paper, we show that piracy has a "positive" impact on maritime trade cost once the impact of the size of the trading countries, the trade imbalance between these countries, their volume trade and other unobservable time-variant factors common to all routes are taken into account.

Figure 2. Evolution of average transport freight rates for two alternative routes

We differentiate between three kinds of incidents according to the extent to which the ship's journey is disrupted: Attempted acts of piracy, boarding acts and hijackings. An attempted piracy act occurs when pirates board a ship and abandon it empty-handed after being discovered, or in instances in which a ship is fired upon without being stopped. Instances of boarding entail actual boarding of a ship by pirates and theft (generally the personal belongings of the crew and/or goods carried for crew maintenance and en-route ship repairs). These incidents may involve violence against the crew. The last type of piracy act, hijacking, consists in the seizure of the ship and its crew, the immobilization of the ship in a coastal area under the control of the pirates and a ransom being demanded in exchange for the crew members, the ship and its cargo. It is most obviously hijackings that are the most disruptive for maritime trade. Figure 3 shows the evolution of the three types of piracy incidents over time between Europe and East Asia.

Figure 3. Number of piracy acts by type on the Europe- East Asia Route

3.2 MEASUREMENT OF TRANSPORT COSTS

One of the main difficulties in analyzing transport costs is that of obtaining reliable data. In the recent economic literature there have been several attempts to measure directly or indirectly transport costs. Some authors used cif/fob ratios as a proxy for shipping costs (Baier and Bergstrand, 2001, Limao and Venables, 2001; Radelet and Sachs, 1998). Since most importing countries report trade flows inclusive of freight and insurance (cif) and exporting countries report trade flows exclusive of freight and insurance (fob), transport costs can be calculated as the difference of both flows for the same aggregate trade. However, Hummels (1999b) showed that importer cif/fob ratios constructed from IMF sources are poor proxies for cross-sectional variation in transport costs and such variable provides no information about changes in transport costs over time. Oguledo and Mcphee (1994) also doubted the usefulness of cif/fob ratios from IMF sources as a proxy of transportation costs.

Several authors have attempted to construct more accurate measures of transport costs. Hummels (1999a, 1999b) use data on transport costs from various primary sources including shipping price indices obtained from shipping trade journals (Appendix 2 in Hummels, 1999b); and freight rates (freight expenditures on imports) collected by customs agencies in United States, New Zealand and five Latin-American countries (Mercosur plus Chile). In addition to cif/fob ratios reported by the IMF, Limao and Venables (2001) use shipping company quotes for the cost of transporting a standard container (40 feet) from Baltimore to sixty-four destinations. The authors pointed out that it is not clear how the experience of Baltimore can be generalized. Martínez-Zarzoso et al. (2003) used data on transportation costs obtained from interviews with logistic operators in Spain. Micco and Perez (2001) used data from the U.S Import Waterborne Databank (U.S. Department of Transportation), where transport cost is defined as "the aggregate cost of all freight, insurance and other charges (excluding U.S. import duties) incurred in bringing the merchandise from the port of exportation to the first port of entry in the U.S.". Sanchez, Hoffmann and Micco (2002) analysed data on maritime transport costs obtained from the International Transport Data Base (BTI). They focused on Latin American trade with NAFTA.

In this paper, we use a newly released database from the OECD which overcomes some of the problems presented by the precedent databases. This database contains maritime trade for 20 importing countries and 218 exporting countries for the period 1991 to 2007, covering different categories of products. The data come from several reliable sources (original customs data from Australia, New Zealand and the United States and also private sources as Containerization International, Drewry Consulting and the Baltic Dry Shipping Index). A sound methodology is used to harmonize these various sets of observations (Korinek, 2008). The advantages of this database in terms of comprehensiveness and time span make it a valuable tool for the study of transport costs (Korinek and Sourdin, 2009a; Korinek and Sourdin 2009b). Figure 4 displays the evolution of the average unit transport cost for four categories of goods (manufactured goods, dirty bulk, crude oil and agricultural goods) exported from Europe (EU15) to Asia.

Figure 4. Evolution over time of average maritime transports cost for four types of goods between Europe and Asia

4 FACTORS EXPLAINING TRANSPORT COSTS

4.1 Model specification

A general formulation of transport costs for commodity *k* shipped between countries *i* and *j*, in a given period of time, can be written as:

$$TC_{ijkt} = F(X_{it}, X_{jt}, v_{ijt}, \omega_k, \mu_{ij}, \varphi_t) \quad (1)$$

where X_{it} and X_{jt} are country specific characteristics, v_{ijt} is a vector of characteristics related to the journey between i and j, ω_k is a product specific effect that captures differences in transport demand elasticity across goods, μ_{ij} represents unobservable heterogeneity that is specific to each trading flow and φ_t unobservable heterogeneity that is time-specific.

GDP and population of the trading countries are used to proxy for country specific characteristics, such as infrastructure and quality of institutions[5]. The vector v_{ijt} includes the trade imbalance between countries i and j, a proxy for economies of scale proxies with the volume traded between countries i and j, and our variable of interest, namely the number of piracy incidents involving hijacking along the trade route linking country i and j. Distance between i and j and other variables related to each bilateral trade relationship could be added to model μ_{ij} but we have preferred to specify bilateral fixed effects μ_{ij} in order to capture all the time-invariant unobserved heterogeneity attached to each pair of trading countries. Product specific dummy variables are used to account for ω_k and time specific dummy variables (φ_t) are added as a proxy for unobserved variables that influence transport costs and are time variant but common for all trading pairs, as for example technological improvements in transport.

Assuming a multiplicative form, a transport cost function is specified as:

$$TC_{ijkt} = Y_{it}^{\alpha_1} Y_{jt}^{\alpha_2} Pop_{it}^{\alpha_3} Pop_{jt}^{\alpha_4} Imb_{ijt}^{\alpha_5} \, XM_{ijt}^{\alpha_6} e^{\beta_1 hijack_{r,t} + \mu_{ij} + \omega_k + \varphi_t + \varepsilon_{ijkt}} \quad (2)$$

where TC_{ijkt} denotes unitary maritime transport cost for each 2-digit HS product category, i denotes the importer country, j denotes the exporter country and t the year, k is the 2-digit level of the HS classification. Y denotes the GPD of the corresponding country, Pop denotes

[5] We also used alternative variables, namely road infrastructure and a liner shipping connectivity index as proxies for infrastructure. The results concerning our target variable were unchanged and are available upon request from the authors.

population. *Imb* is the trade imbalance between country *i* and *j* calculated as the difference between exports from *i* to *j* and imports of *i* from *j* in absolute value. *XM* denotes trade volumes in tons calculated as the sum of exports and imports, $Hijack_{rt}$ denotes the number of piracy incidents involving hijacking along the trade route *r* in year *t* linking country *i* and *j*. Other type of piracy incidents (boarded ships and attempted attacks) will also be considered as explanatory variables. μ_{ij}, ω_k and φ_t denote the different sets of fixed effects described above. Finally, ε_{ijkt} is the error term that is assumed to be identically and independently distributed.

Taking natural logarithms of equation (2) we obtain a linear version of the general specification given by,

$$\ln TC_{ijt} = \alpha_1 \ln Y_{it} + \alpha_2 \ln Y_{jt} + \alpha_3 \ln Pop_{it} + \alpha_4 \ln Pop_{jt} + \alpha_5 \ln Imb_{ijt} + \alpha_6 \ln XM_{ijt} + \beta_1 hijack_{rt} + \mu_{ij} + \omega_k + \varphi_t + \varepsilon_{ijkt} \qquad (3)$$

where ln denotes natural logarithms and all the variables have been described after equation (2).

4.2 Data and variables

In this section we describe the data and variables used in our empirical work. Sources and variable definitions are listed in Table A.2. The dependent variable (*TC*) is obtained from the OECD data base on maritime transport costs. We use the maritime transport costs between the European Union and 13 destinations in Asia[6] for each HS 2 digits class of goods. We differentiate four types of goods: manufactured goods, raw materials, agricultural goods and crude oil. The target variable is *t_hijack* that stands for the number of hijacked ships on a

[6] For the European Union, the maritime transport cost database considers the EU15 as a single emitter of data. Data for Bulgaria, Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland and Slovenia are also available. The Asiatic countries in our dataset are Bangladesh, China, Indonesia, India, Japan, South Korea, Malaysia, The Philippines, Singapore, Thailand and Vietnam. Australia was added to this group.

particular route. Each pair of country is associated with one trade route. We expect *t_hijack* to correlate positively with maritime transport costs. Other variables that measure piracy incidents are: *t_boarded*, the number of incidents in which a ship has been boarded but not hijacked; and *t_attempted*, the number of attempted attacks that do not succeed. These two variables will also be used in the empirical analysis as additional explanatory variables.

Additional explanatory variables are: GDP (Y_{it} ; Y_{jt}), population (Pop_{it} ; Pop_{jt}), trade imbalances (Imb_{ijt}) and trade volumes (XM_{ijt}). The source for the three first variables is the world development indicators dataset (WDI) from the World Bank. GDP and population of the importer and exporter countries are used as control variables for country characteristics. The trade imbalance is expected to be negatively correlated with bilateral maritime transport cost if bidirectional transport costs between two regions are jointly determined, since transport costs will depend on the relative demand for transports between regions (Jonkeren, Demirel Ommeren and Rietveld, 2010). Finally the trade volume is expected to have a reducing effect on transport prices, since routes characterized by intense trade may foster competition and reduce transportation costs, this variable has been obtained from Eurostat. Summary statistics of the described variables are presented in Table 1.

Table 1. Summary statistics

An alternative variable that could be used instead of piracy events is The Lloyd's classification of a war zone. In Table A.3 we show the evolution of the different zones reported through the last 6 reports of Joint War Committee available on line. We would like to underline that for most of the observations, when a country is listed the war zone concerns the limits of the national waters of this country. This definition, pertinent and useful when a war occurred and the insurance companies require a strict defined geographical perimeter, seems to us limitative in order to grasp the piracy phenomena. With the only exception of thieves in ports, the pirates' attacks occur en route. It is true that most of these attacks take place not far from a coastal area but nonetheless pirates do not feel bound by the territorial limits defined internationally (particularly in the zones were several national maritime zone are in contact or very close as in the Gulf of Aden or the Strait of Malacca). The joint war committee has tackled this problem by defining broader zone of danger (Gulf of Aden, Sulu Archipelago). In this instance, the Gulf of Aden zone juxtaposes quasi perfectly with the Red Sea Gulf of Aden maritime zone defined in our paper. Even if similar zones are defined the war zone classification presents the important disadvantages of not revealing any information on the intensity of the conflict and of presenting very few variations over time. By providing a count of the number of incidents over time for each geographic zone and trade route defined, the IMB database, in our sense, was more suitable for the type of study we aimed to do.

5 Empirical application and main results

5.1 Main results

Equation (3) has been estimated using a least squares dummy variable estimator (LSDV) with different sets of dummies to control for unobservable heterogeneity. To test whether piracy acts have different impacts on transport costs depending on the nature of transported goods, we estimate Equation (3) for four different types of goods (agriculture, manufactures, raw materials and crude oil) and for two different types of transport (containers and tankers and dirty bulk). Tow type of piracy, namely number of hijacked ships and number of boarded ships enter the trade cost equation significantly[7]. The baseline estimation results are shown in Table 2 (LSDV estimates). In Table 3, we estimate Equation (3) with the variables *t_hijack* and *t_boarded* lagged two years[8]. In doing so, we control for the possibility that shipping contracts are agreed upon in advance. The estimated coefficients for the different sets of fixed effects (k, ij, t) are not shown[9]. Both Tables report the results assuming common coefficients for all types of products in the first column and specific estimates for four different types of goods, namely manufactures, agricultural goods, raw materials and crude oil in columns 2, 3, 4 and 5, respectively.

[Table 2,3]

In both estimations (LSDV and LSDV with lagged piracy variables) the piracy coefficients have the expected positive signs and are statistically significant at conventional levels for total trade, manufactures and agricultural products. The coefficients in Table 3 are slightly higher for *t_hijack* for total trade, manufactures and agricultural products and turn out to be also positive and significant for raw materials and crude oil. One additional hijacked ship results in an increase of around 1.6 percent (Table 3, column 1) of maritime transport costs between Europe and Asia. A positive and significant effect is also found for manufactures and agricultural goods considered separately in both specifications and for raw materials and crude oil only using lagged values of piracy incidents. One additional act of hijacking results in an increase of around 1.5 percent and 1.4 percent of maritime transport costs for manufactured goods and agricultural goods respectively. When considering boarded ships as piracy acts, the impact on transport costs

[7] Attempted attacks was also originally considered but it was not statistically significant and it is not included in the final estimations.
[8] We thank the suggestion made by one anonymous referee. Similar results obtained with the variable lagged one period are available upon request.
[9] These results are available upon request from the authors.

is lower but also shows a positive and statistically significant effect for all categories of goods in Table 2 and for the two main categories (agricultural and manufacturing products) in Table 3.

According to our data, the unit maritime transport cost of footwear was 0.505 US$ in 2007 that for a shipment of 10000 units of footwear between Europe and Asia amounts to 5050 US$. One more act of hijacking translates into an increase of 75.75 US$ for the shipment. Furthermore, if we also consider the number of piracy acts resulting in the successful boarding of a ship, the increase in transport costs will be of 96 US$. The coefficient on the variable *t_boarded* is not statistically significant for raw materials and for crude oil when used lagged values (Table 3, columns 4 and 5). However for these two categories of goods the number of observations available is very low in comparison with manufactures and agricultural products. This is probably the reason why the results are less robust to changes in the specification.

5.2 Robustness check

We mentioned that there is a certain level of controversy in the scientific community concerning the fact that pirates may choose the ships they attacked according to the good transported. Since transport costs depend on the nature of transported goods, the piracy variable in Equation (3) might be endogenous. As a robustness check we estimate Equation (3) for ships transporting containers on one side and for tankers and ships transporting dirty bulk on the other side. Tankers are one of the main categories of ships under attack according to the ICC database (see Table A.4). However, it seems that very few attacks on this kind of vessels are successful and result in hijacking. Among the 30 attacks on oil tankers in 2008 only one has been successful[10]. Among the observations in our dataset, crude oil is transported by tanker but also by dirty bulks ships.

[10] The successful attack of the Sirius Star a new launch Saudi Arabian super tanker made the top of the news for several weeks during 2008. It has been ever since the biggest ship captured by Somali pirates.

Therefore we have aggregated these two categories. The results are shown in Table 4 and indicate that the impact of piracy is greater for tankers and ships transporting dirty bulk.

We tried also several sets of instruments and finally instrumented the number of vessels hijacked with the number of hijacks in the three previous years. The model is estimated using a Generalized Method of Moments (GMM) that is robust to heteroskedasticity and autocorrelation of unknown form. We also tried with ship boarding and boarding attempts as instruments, but the variables are correlated with the number of vessels hijacked and are not independent of the type of transported goods and thus correlated with the error term in our transport cost equation.

The results of the IV estimation when a GMM approach is taken are reported in Table 5 for all goods (colum 1) for manufactures (column 2) and for agriculture (column 3). We were not able to find valid instruments for crude oil and raw materials. Our variable of interest stays positive and significant and the magnitude is similar to the one obtained in Table 3. It is worth noting that although widely use in the empirical literature, the use of internal instrument may not the best strategy. We leave this issue for further research.

[Table 5]

6 CONCLUSION

In this paper we quantify the impact of maritime modern piracy on maritime transport cost of trade between European Union countries and Asian countries. The main results indicate that the effect is substantial and significant. Piracy increases maritime trade cost between Europe and Asia by a non negligible amount.

The presence of failed or weak states along the main maritime trade route between Europe and Asia harm selectively the trade between the two continents. In a context where it has been demonstrated that small downward variation in trade barriers could allow the entrance of smaller firms on international markets (Melitz, 2003; Chaney, 2008), the disadvantage of higher transport cost between Europe and Asia harms the interest of Europe in comparison to its competitors on the expanding markets of Asia.

In addition, the increase of transport costs due to maritime piracy could lead to some shipping companies to exploit the Artic route between Europe and Asia passing along the coasts of Russia. The route has been free of ice for at least three years from the end of August to the beginning of October. Without the cost of employing ice breaker ships to escort commercial vessels, the route has been demonstrated as more economical than the Suez route (Xu et al. 2011). Adding the price of maritime piracy to the Suez route, the north route, at least for some months, become an interesting and safe alternative.

Until now, the various military operations put in place in the Gulf of Aden and in particular the operation Atalanta of the European Union have not succeeded to curb down the occurrence of piracy incidents, but it has forced the pirates to extend their range of action. It is only by reducing significantly the number of hijacking that the European navies could transfer the supplementary cost to ship merchandizes from private shipping companies and consumers to national governments and taxpayers. Future research should be directed towards determining the loss of welfare and the markets distortions associated with each of these two options.

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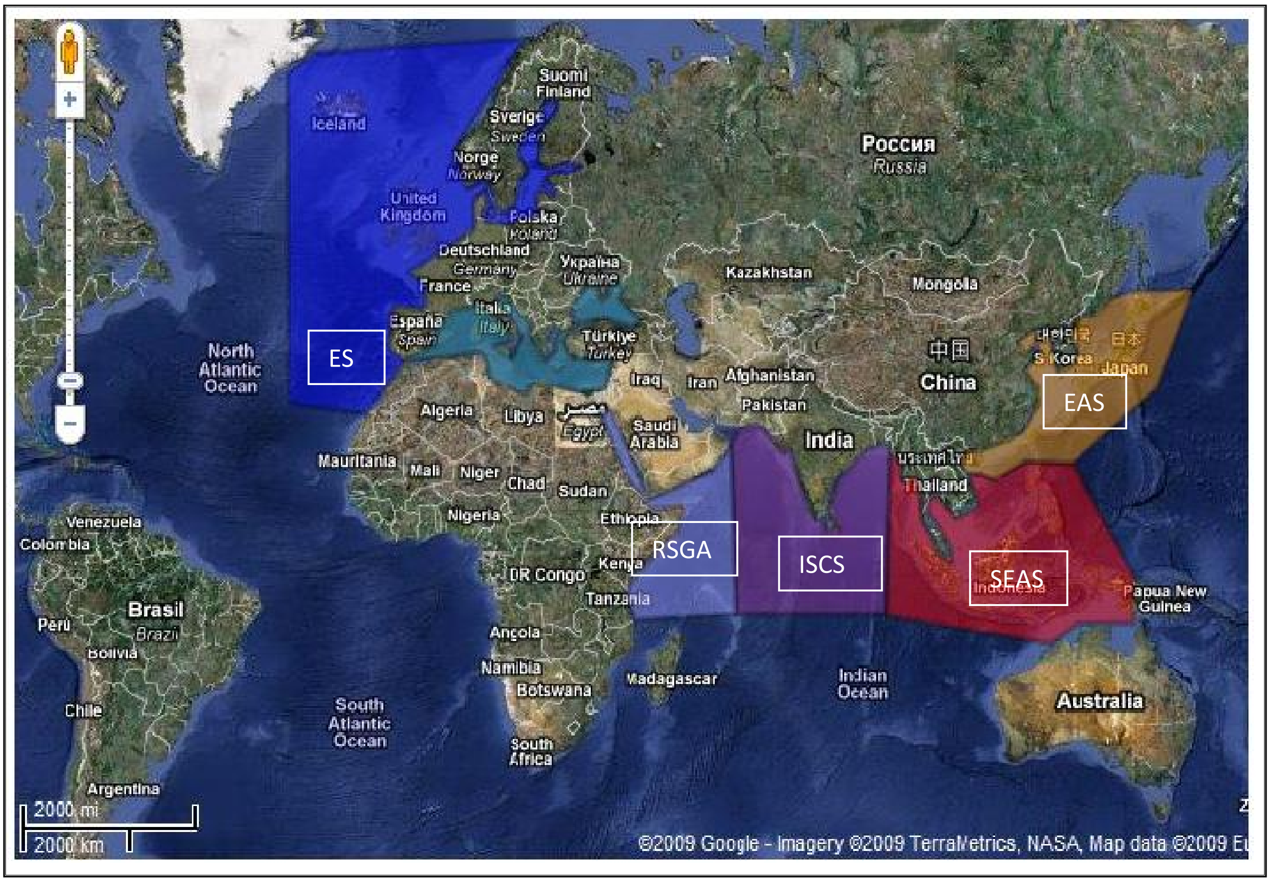
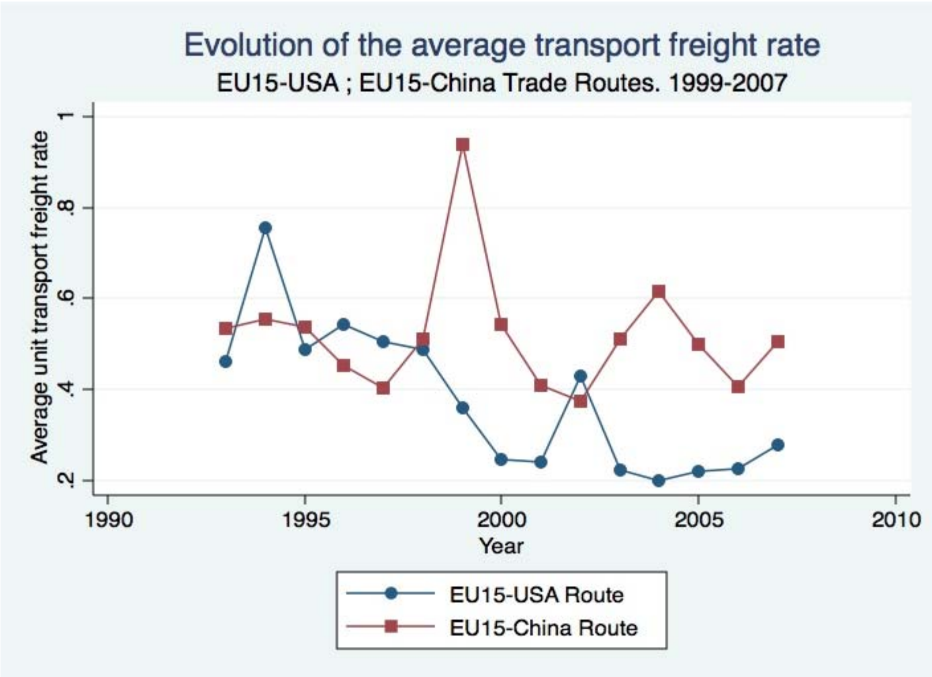
Figure 1: Maritime regions.



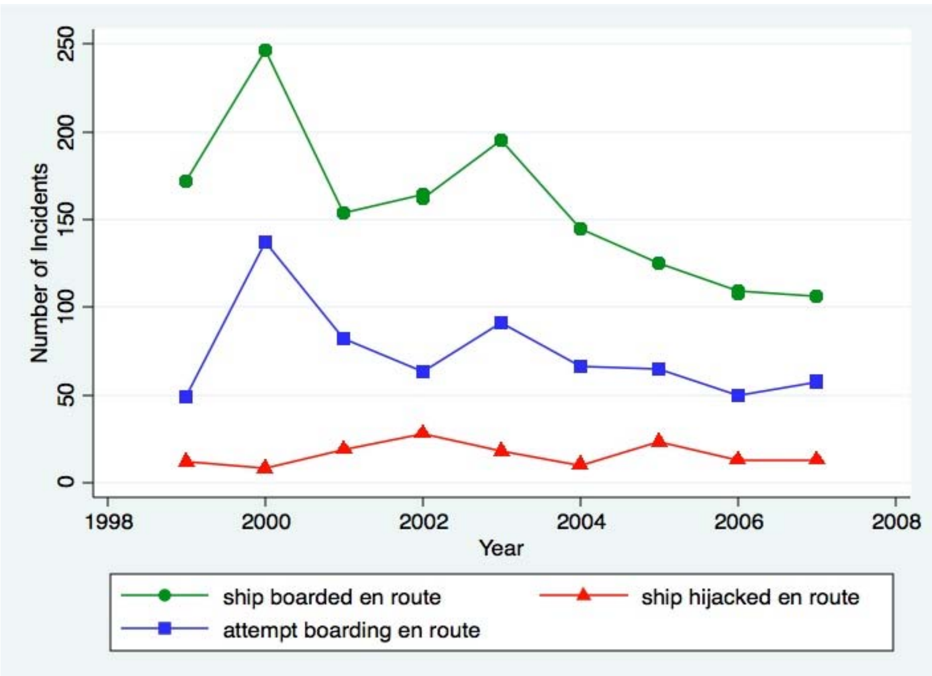
Source: Self-created using data from IMB Piracy Reporting Center, International Maritime Bureau, ICC Commercial Crime Services, London, UK. http://www.icc-ccs.org

Figure 2. Evolution of average transport freight rates for two alternative routes



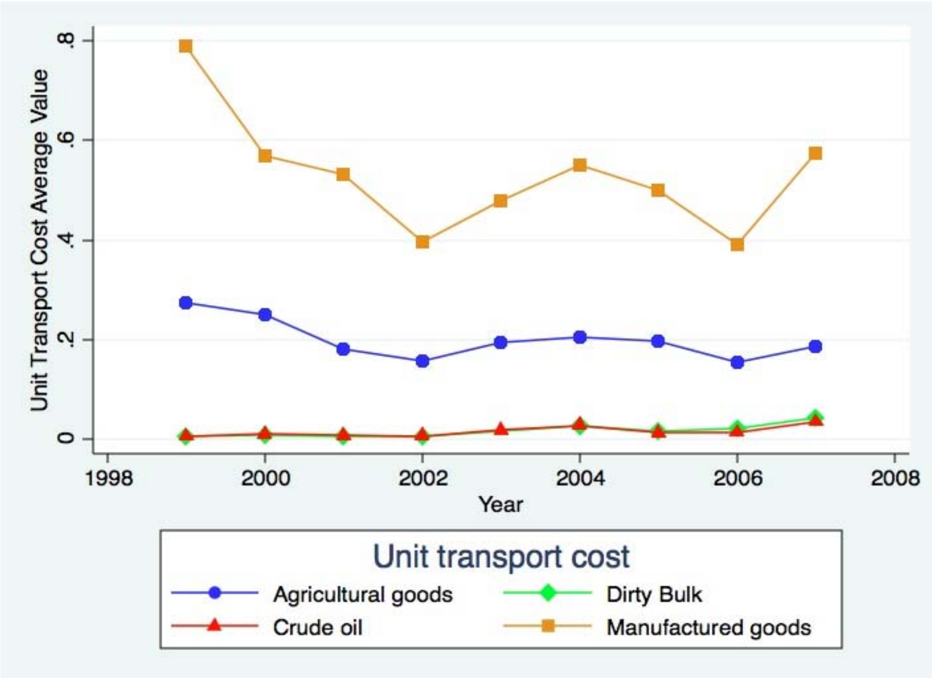
Source: Authors' own elaboration.

Figure 3. Number of Piracy Incidents on the Europe East Asia Trade Route



Source: Authors' own elaboration.

Figure 4. Average Maritime unit transport cost for 4 types of goods (EU to Asia, dollars)



Source: Authors' own elaboration.

Table 1. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
TC	16152	0.3415101	1.014443	0	49.9656
Ln Y_i	16152	27.8959	2.241851	22.01682	30.38747
Ln Y_j	16152	28.17277	1.926653	24.21019	30.38747
Ln Pop_i	16152	18.59602	1.689092	12.86876	20.99929
Ln Pop_j	16152	18.6692	1.507516	15.19143	20.99929
t_hijack	16152	14.34243	6.613979	1	28
Ln Imb_{ij}	16152	135.6421	52.09402	34	246
Ln XM_{ij}	16152	64.45369	27.446	12	137

TC denotes unitary maritime transport cost.

Table 2. Baseline Results

LSDV	**All goods**	**Manuf.**	**Agric.**	**Raw Mat.**	**Crude Oil**
t_hijack	0.009**	0.007*	0.010*	-0.011	-0.042
	2.213	1.714	1.862	-0.778	-1.377
t_boarded	0.004***	0.003***	0.006***	0.016**	0.017**
	8.218	2.87	5.959	2.36	2.472
Ln Y_i	-0.025	-0.014	-0.081	1.124	1.094*
	-0.456	-0.168	-1.269	1.157	2.06
Ln Y_j	0.170***	0.191***	0.117	2.344***	1.895**
	2.922	2.785	1.247	5.613	2.598
Ln Pop_i	-0.428	-0.264	-0.001	-17.843**	-14.560*
	-0.98	-0.396	-0.002	-2.857	-1.947
Ln Pop_i	-0.241	-0.176	0.791	-55.363***	-53.822***
	-0.372	-0.21	1.393	-5.821	-5.346
ltradeim	-0.004	0.002	-0.003	-0.349*	-0.133
	-0.411	0.141	-0.244	-1.925	-0.592
lXM	-0.028	-0.087**	0.025	0.244	-0.176
	-1.379	-2.269	0.966	1.156	-0.337
r2_a	0.697	0.685	0.573	0.696	0.784
N	15758	11319	4244	110	85
rmse	0.4984662	0.5018692	0.4471734	0.6136655	0.5840678
ll	-11314.76	-8198.159	-2569.04	-83.46222	-57.91903

Note: t-statistics are reported, calculated using robust standard errors clustered by country pair. Ln expresses natural logarithms. All regressions are with time, sector 2-digit and trading-pair fixed effects. ***, **, *, indicate significance at 1%, 5% and 10%, respectively.

Table 3. Results with piracy variables and trade volumes lagged.

LSDV	**All goods**	**Manuf.**	**Agric.**	**Raw Mat.**	**Crude Oil**
t_hijack (t-2)	0.016***	0.015***	0.014***	0.078***	0.063**
	7.241	4.797	5.054	3.41	3.073
t_boarded (t-2)	0.004***	0.004***	0.005***	-0.008	-0.005
	4.111	2.906	5.713	-0.744	-0.995
Ln Y_i	-0.081	-0.105	-0.071	-0.501	1.472***
	-1.008	-1.176	-0.603	-0.213	4.229
Ln Y_j	0.372***	0.369***	0.319**	2.089*	2.074***
	3.817	4.017	2.236	2.215	5.624
Ln Pop_i	-0.024	0.696	-1.347	-33.833	-7.557
	-0.039	0.918	-1.318	-1.553	-1.607
Ln Pop_i	-0.253	-0.539	1.349	-48.164**	-38.839***
	-0.375	-0.705	1.313	-2.509	-6.184
Ln Imb_{ij}	-0.02	-0.017	-0.007	-0.269	-0.293***
	-1.536	-1.284	-0.359	-1.465	-3.292
Ln $XM_{ij, t-1}$	0.004	-0.047	0.01	0.167	-0.094
	0.107	-0.853	0.286	0.828	-0.644
r2_a	0.741	0.734	0.601	0.636	0.812
N	10847	7831	2899	60	57
RMSE	0.4396452	0.4414019	0.3954396	0.6187129	0.5100989
ll	-6406.845	-4651.623	-1390.041	-38.39437	-26.05642

Note: t-statistics are reported, calculated using robust standard errors clustered by country pair. Ln expresses natural logarithms. All regressions are with time, sector 2-digit and trading-pair fixed effects. ***, **, *, indicate significance at 1%, 5% and 10%, respectively.

Table 4. Results for Containerized trade and for Tankers and dirty bulk

LSDV	2 lags		1 lag	
	Containers	**DirtyBulk+tankers**	**Containers**	**DirtyBulk+tankers**
t_hijack $_{(t-2)/(t-1)}$	0.013***	0.060***	0.014***	0.021**
	7.811	9.423	6.666	2.237
t_boarded $_{(t-2)/(t-1)}$	0.005***	-0.005	0.004***	-0.005
	4.687	-0.934	4.676	-1.685
Ln Y_i	-0.126*	0.700**	-0.049	0.596
	-1.698	2.141	-0.758	1.671
Ln Y_j	0.347***	1.471***	0.127**	0.022
	3.622	3.158	2.543	0.041
Ln Pop_i	0.463	-4.672	-0.103	-3.764
	0.745	-0.913	-0.253	-0.837
Ln Pop_i	-0.287	-37.920***	0.307	-22.894**
	-0.448	-5.452	0.535	-2.862
Ln Imb_{ij}	-0.01	-0.218**	-0.009	-0.103
	-0.803	-2.706	-0.589	-1.439
Ln $XM_{ij, t-1}$	-0.028	0.095	0.021	0.031
	-0.602	0.72	0.553	0.181
r2_a	0.732	0.738	0.728	0.681
N	10972	205	12735	243
RMSE	0.4407706	0.5555792	0.4460124	0.60134
ll	-6514.1	-149.9926	-7720.481	-200.5523

Note: t-statistics are reported, calculated using robust standard errors clustered by country pair. Ln expresses natural logarithms. All regressions are with time, sector 2-digit and trading-pair fixed effects. Columns 1 and 2 (3 and 4) present the results when the second lag (first lag) of the piracy variables are used. ***, **, *, indicate significance at 1%, 5% and 10%, respectively.

Table 5. Generalized Method of Moments estimation results

GMM	**All goods**	**Manuf.**	**Agric.**
t_hijack	0.011***	0.009	0.014***
	2.858	1.503	3.108
t_attempt	0.006***	0.005**	0.007***
	4.255	2.197	3.915
Ln Y_i	-0.276***	-0.301***	-0.306**
	-3.454	-3.141	-2.127
Ln Y_j	0.325***	0.380***	0.141
	3.913	3.912	0.942
Ln Pop_i	0.052	0.884	-1.508*
	0.105	1.49	-1.709
Ln Pop_i	-1.624***	-1.908***	0.008
	-3.167	-3.044	0.011
Ln Imb_{ij}	0.001	0.005	0.003
	0.073	0.291	0.126
Ln $XM_{ij, t-1}$	-0.021	-0.071	0.013
	-0.606	-1.412	0.267
R2	0.75	0.744	0.619
N	9028	6522	2415
Hansen	8.729	4.212	5.05
(prob)	0.071	0.378	0.28

Note: t-statistics are reported, calculated using robust standard errors clustered by country pair. Ln expresses natural logarithms. All regressions are with time, sector 2-digit and trading-pair fixed effects. ***, **, *, indicate significance at 1%, 5% and 10%, respectively.

Appendix

Table A.1. Maritime Region Navigated according to each trade route.

Maritime Route	Maritime regions navigated				
	European Seas (ES)	Red Sea/ Gulf of Aden (RGSA)	Indian Sub Continental Seas (ISCS)	South East Asian Seas (SEAS)	East Asian Seas (SEC)
Europe - Indian Sub Continent	X	X	X		
Europe - South East Asia	X	X	X	X	
Europe - East Asia	X	X	X	X	X

Source: Authors' own elaboration.

Table A.2. Sources and variables

Dependent Variables	Description	Source
TC_{ijt} : Unit Maritime Transport Cost from i to j in year t	Cost in $ to transport one unit of good from a country i to a country j in year t	OECD
Independent Variables	Description	Source
Y_{it} : Exporter's income	Exporter's GDP, PPP (current $)	WDI
Y_{jt} : Importer's income	Importer's GDP, PPP (current $)	WDI
t_boarded	number of ships boarded by pirates on a particular route and year	IMB
t_hijack	number of ships hijacked by pirates on a particular route	IMB
t_attempt	number of attempted piracy acts on a particular route	IMB
Imb_{ijt}	Trade imbalance between country i and j	Calculated from the WDI
XM_{ijt}	Trade volumes between countries i and j in year t	Eurostat

$Dist_{ij}$: Distance	Distances between country capitals of trading partners (km)	CEPII

Table A.3: Maritime War Zone

Listed Areas	1/8/11	3/3/11	16/11/10	2/8/10	11/3/10	25/11/09
Africa						
Benin	1	0	0	0	0	0
Djibouti excluding transit	1	1	1	1	1	1
Eritrea, but only South of 15o N	1	1	1	1	0	0
Gulf of Guinea	1	0	0	0	0	0
Ivory Coast	1	1	1	1	1	1
Libya	1	1	0	0	0	0
Nigeria	1	1	1	1	1	1
Somalia	1	1	1	1	1	1
Indian Ocean / Arabian Sea / Gulf of Aden / Gulf of Oman / Southern Red Sea	1	1	1	1	1	1
Asia						
Pakistan	1	1	1	1	1	1
Sri Lanka	0	0	0	0	1	1
Thailand, but only the area of the southern Gulf coast	0	0	0	0	0	1
Eastern Europe						
Georgia	1	1	1	1	1	1
Indonesia						
The port of Balikpapan (SE Borneo)	1	1	1	1	1	1
Borneo, but only the north east coast	1	1	1	1	1	1
The port of Jakarta	1	1	1	1	1	1
Sumatra, but only the north eastern coastt	1	1	1	1	1	1
Middle East						
Bahrain excluding transit	1	1	1	1	1	1
Iran	1	1	1	1	1	0
Iraq, including all Iraqi offshore oil terminals	1	1	1	1	1	1
Israel	1	1	1	1	1	1
Lebanon	1	1	1	1	1	1
Qatar excluding transit	1	1	1	1	1	1
Saudi Arabia excluding transit	1	1	1	1	1	1
Yemen	1	1	1	1	1	1
Philipinnes						
Mindanao	1	1	1	1	1	1
Sulu Archipelago	1	1	1	1	1	1
South America						
Venezuela	1	1	1	1	1	1

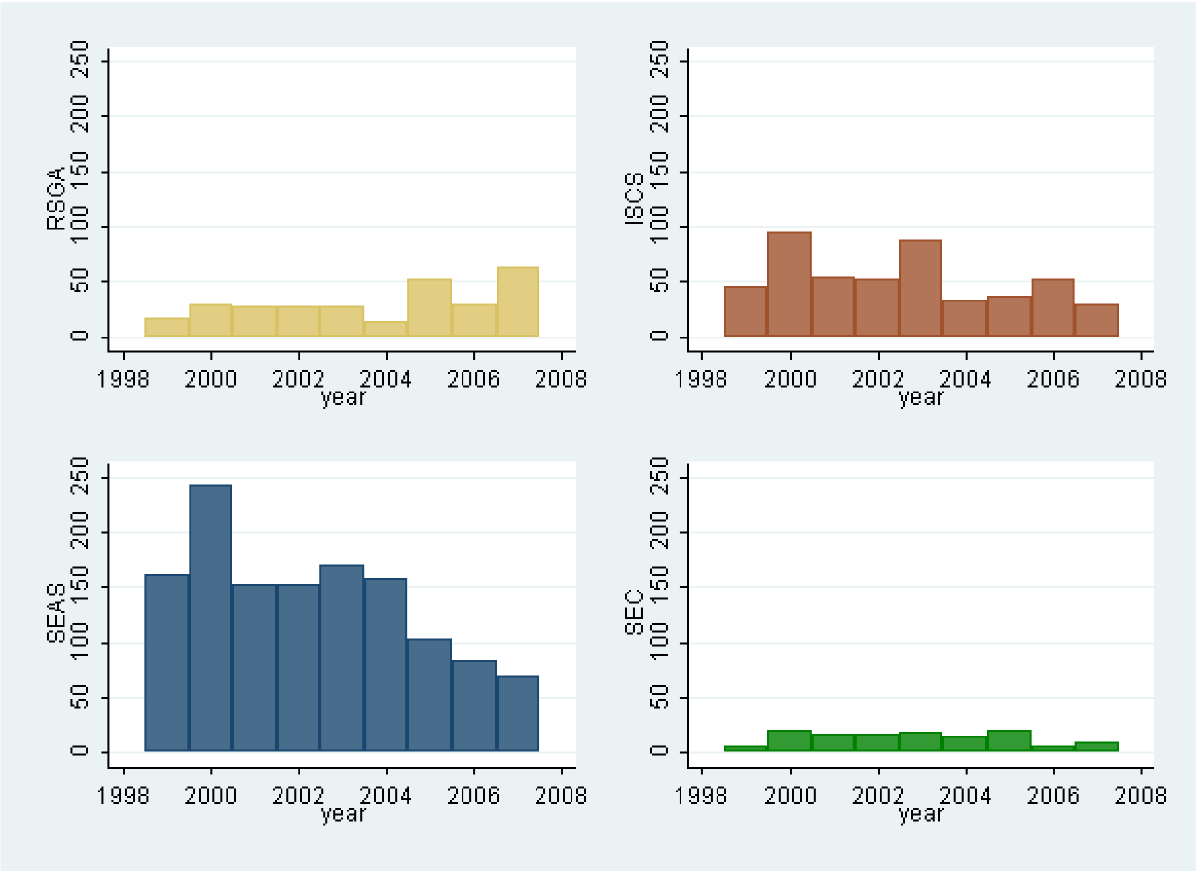
Source: JWLA Hull War, Strikes, Terrorism and Related Perils, reports 2011, 2010, 2009 (www.lmalloyds.com and www.iua.co.uk.)

Table A.4: Type of vessels attacked (%)

Type of Vessels	2003	2004	2005	2006	2007	2008
Bulk Carrier	25.62%	22.19%	29.35%	23.85%	12.17%	16.38%
Container	12.58%	14.59%	10.87%	20.50%	20.15%	16.72%
General cargo	16.40%	11.55%	16.67%	12.55%	13.69%	12.97%
Refrigerated	1.57%	3.04%	1.09%	1.26%	2.66%	2.73%
Tanker Chem / Product	11.01%	17.02%	15.58%	14.64%	19.77%	18.77%
Tanker Crude Oil	9.44%	5.17%	7.97%	3.77%	9.51%	10.24%
Tanker LPG	3.15%	3.95%	1.81%	1.67%	1.90%	2.05%
Trawler / Fishing	6.29%	5.47%	2.54%	7.53%	6.08%	3.07%
Tug	4.27%	7.29%	4.71%	3.77%	2.66%	5.46%
Yacht	3.37%	3.34%	2.54%	4.18%	3.04%	3.07%
Other	6.29%	6.38%	6.88%	6.28%	8.37%	8.53%

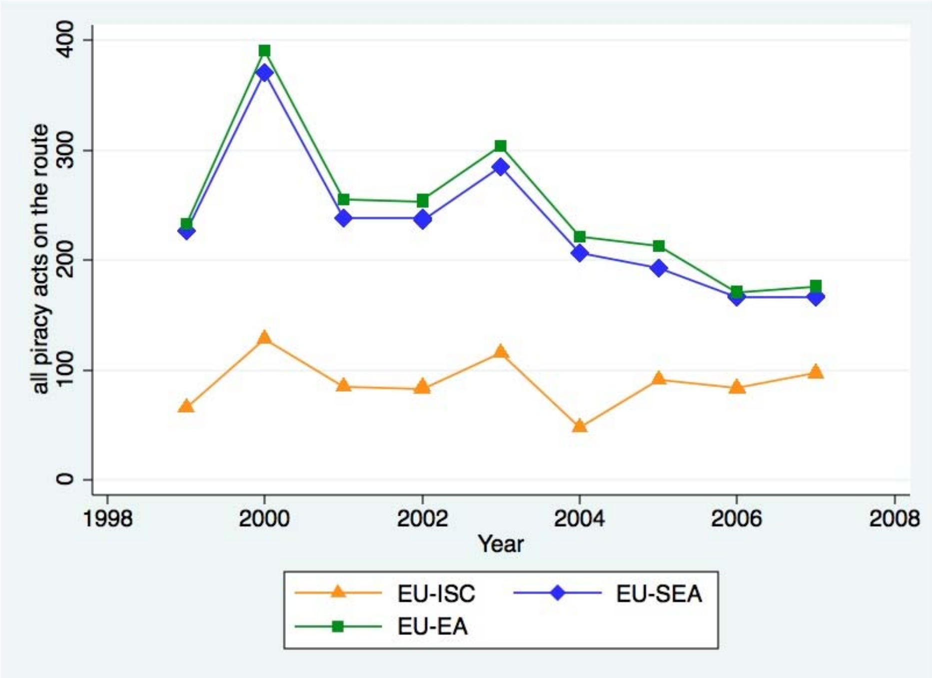
Source: IMB report 2008

Figure A.1 Number of piracy incidents in each region between 1999 and 2008



RGSA is for Red Sea and Gulf of Aden; ISCS is for Indian Sub Continent Seas; SEAS is for South East Asia Seas; EAS is for East Asia Seas. Source: Authors' own elaboration.

Figure A.2 Number of incidents on three different routes linking Europe and Asia



Source: Authors' own elaboration.