Assessment of the economic impact of market-based measures

Prepared for the Expert Group on Market-based Measures, International Maritime Organization

August 2010

: vivideconomics

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Executive Summary

The International Maritime Organization's Marine Environment Protection Committee set up its Market-Based Mechanisms Expert Group (MBM-EG) in 2010 to assess the feasibility and potential economic impacts of options for the reduction of greenhouse gas emissions from international shipping. The objective of this report is to contribute to the MBM-EG's assessment of economic impacts. The report makes no assumptions about the type of MBM which might be imposed; it examines the effects of an increase in bunker price only, resulting from an unspecified MBM on the following selection of shipping routes and product markets[1]:

- Capesize iron ore to China;
- very large crude carrier (VLCC) crude oil to South Korea and the US Gulf Coast;
- Panamax grain into six developing countries; and
- containers from Asia to Europe.

The steps of the analysis for any given market are as follows:

- determine the elasticity of the freight rate with respect to the bunker price (the percentage change by which freight rates increase in response to a 1 per cent increase in the bunker price) through original econometric analysis;
- estimate the resulting increase in freight rates from an 10 per cent increase in the bunker price;
- compile data on the prices, quantities sold and market shares of both domestic producers and importers in the relevant market; and
- estimate the potential impacts of imposing an additional cost on sea-based,

[1] The impact of the efficiency-based measures, in particular, may not be well represented by an increase in bunker fuel prices. Indeed, it is possible that the efficiency based measures would lead to a reduction in the share of bunker fuels in the total costs of shipping.

but not land-based producers, deriving the rate of cost pass-through, overall changes in price and quantity demanded, changes in market share, and other related figures.

The iron ore and crude oil examples are examined using a detailed quantitative economic model. Due to time constraints, the grain and container examples make use of more approximate calculations. Sensitivity analyses examining 5 and 15 percent increases in bunker price are included in an annex.

The average elasticity of the freight rate with respect to bunker prices across a variety of routes is estimated as 0.37 for VLCCs, 0.25 for Panamax grain vessels, 0.96 for Capesize ore vessels and 0.11 for container ships. The elasticity is one of the main determinants of the magnitude of impacts induced by a bunker price increase in a product market. The size of the freight rate in relation to the product price (i.e. *ad valorem*) is also important.

To the extent that the percentage increase in the freight rate is less than the increase in the bunker price, then some portion of the cost of market-based measures will ultimately be borne by ship owners. The distribution of impacts between domestic and overseas producers and domestic consumers is linked to the cost pass-through rate, i.e. the ability of maritime importers to pass on costs to local consumers. These are influenced by the share of imports in consumption and the competitiveness of the destination market.

Here is a summary of the findings for each product market.

The confluence of three factors leads the **Chinese iron ore market** to see the biggest impacts of those examined, in terms of the highest price increase (around 1.5 per cent) and the largest changes in domestic/importer market share (+/- 13 percentage points). The three factors are: a high freight rate elasticity, a high *ad valorem* freight rate, and a moderate, 50 per cent, dependence on sea-borne imports. Changes in market share are not shared evenly by exporting countries: the effects on individual exporting countries depend on their distance from China and the costs of their firms. Australia sees relatively little impact due to its proximity and large, low cost firms. Brazil sees a lesser impact than India, despite its greater distance; this is because

Brazillian production is dominated by a large low cost firm, while Indian production is characterised by a large number of higher cost firms.

The **South Korean and US crude oil markets** are estimated to only see small percentage changes in the volume and provenance of crude oil imports from a 10 per cent increase in the bunker price, despite high cost pass-through and (in the case of South Korea) total dependence on sea-borne imports. Crude oil is a high value product compared to its freight costs and the bunker price increases the *ad valorem* freight rate by only a small percentage. Price increases in these markets are 0.1 per cent or less, and changes in the respective market shares of land and sea-based producers in the US case are minimal.

A diverse range of **developing country grain markets** is examined, varying greatly in their dependence on sea-borne imports. The price increases following a 10 per cent bunker price increase are 0.7 per cent or less, even in cases of high import dependence, due to the relative insensitivity of grain freight rates to bunker price. In most cases, the estimated cost of bunker price increases is largely borne by domestic consumers, but where cost pass-through is low there is a more even distribution of costs between producers and consumers.

The shipping of **apparel and furniture** by container is also examined. Cost pass-through rates are estimated to be approximately 50 per cent and 60 to 90 per cent respectively, depending on the market share of overseas exporters. Higher *ad valorem* freight rates and a greater share of sea-borne imports induce greater consumer impacts for furniture than apparel. Nevertheless, container freight rates exhibit considerably lower price elasticity with respect to bunker price than do bulk freight rates. For this reason, product prices increase by 0.2 per cent or less.

Across all the cases examined, only in the case of iron ore is the price rise estimated to be greater than one per cent. It should be emphasised that the market changes in this report are projections based upon an equilibrium model with all other characteristics of the shipping market being held constant. Over the medium term, it may be that normal changes in freight rates due to the dynamics of global oil, shipping and product markets will dwarf any changes due to a MBM.

Contents

List of tables

List of figures

1 Introduction

1.1 Report objectives

In recent years several measures to regulate greenhouse gases from shipping have been proposed by national governments and other organisations. The International Maritime Organization's Marine Environment Protection Committee set up its Market-Based Mechanisms Expert Group (MBM-EG) in 2010 to assess the feasibility and potential economic impacts of the various options formally submitted to it.

The objective of this report is to contribute to the MBM-EG's assessment by estimating the economic effects of an increase in the bunker price, resulting from the introduction of a MBM. The effects are presented in this report for a selection of ship types, shipping routes and product markets. Statistical techniques are used to estimate the elasticity of freight rates with respect to bunker price, and an economic model is used to estimate the pass-through of costs resulting from the MBM to consumers and producers.

The following combinations of ship type and product were analysed:

- Capesize iron ore to China;
- very large crude carrier (VLCC) crude oil to South Korea and the US Gulf Coast;
- Panamax grain into six developing countries;
- containers from Asia to Europe.

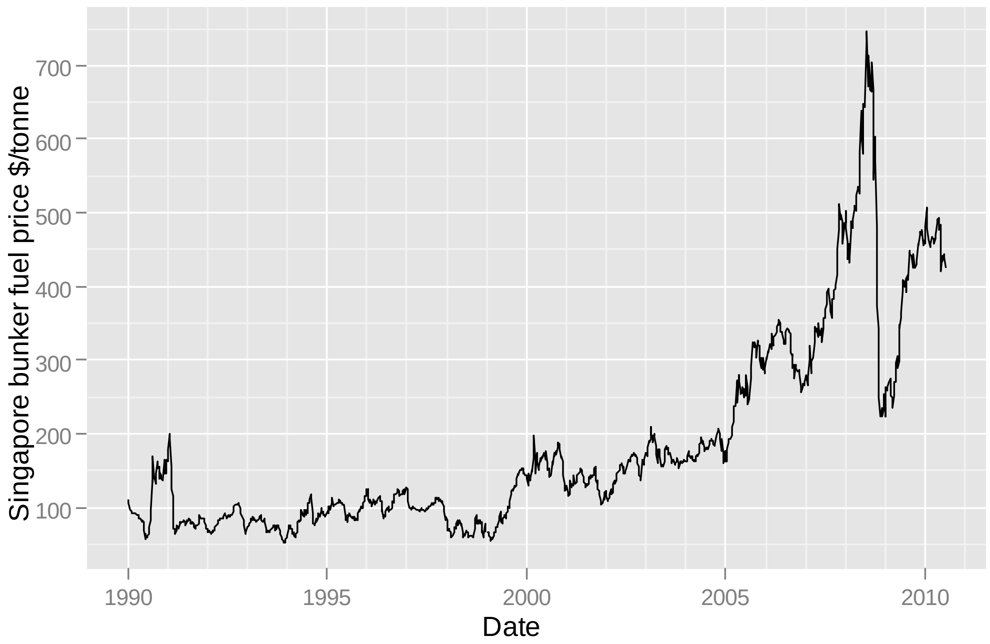
Each of the first three encompasses several routes from major exporters to the country of destination, and all draw on data for several routes. A detailed quantitative economic model is employed in the first two, while, due to time constraints, approximate calculations are used in the latter two, based on accounting relations and previous experience using detailed models. This is the scope of work, which is formally set out in Annex 1.

The report makes no assumptions about the type of MBM which might be introduced, nor how a carbon price would be set. It simply examines the effects of a 10 per cent increase in bunker price. Sensitivity analysis to 5 and 15 per cent increases is included in Annex 4.

1.2 The economic framework

There has been considerable variation in bunker price over the past decade. Figure 1 shows the Singapore bunker fuel price over the period 1990–2010. The price showed a general upward trend between 2000 and mid-2008, increasing five-fold over this period, followed by a sharp drop. Any increase in the bunker price of the order of 5 to 15 per cent would be much smaller than these price fluctuations.

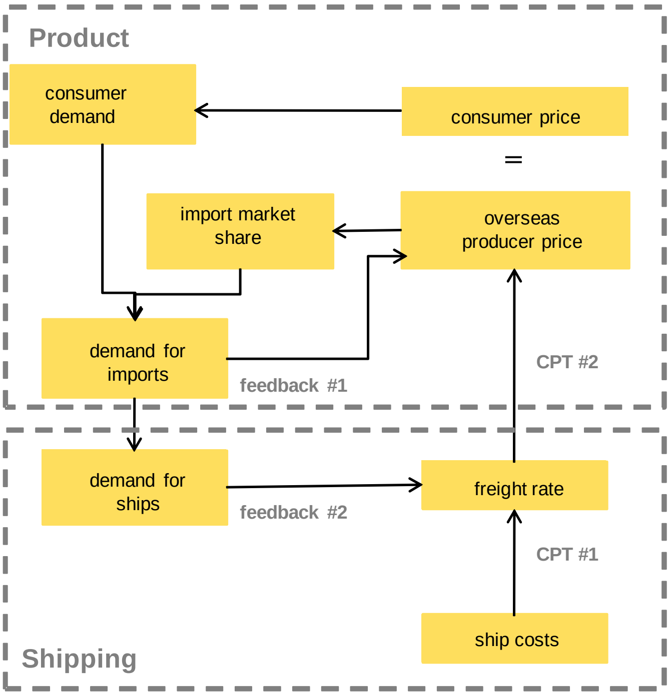
Figure 1 Bunker fuel price generally rose until mid-2008 before falling sharply



Source: Vivid Economics and Clarksons data

A bunker price increase would be felt by ship owners, producers of goods and consumers. The sequence by which the impacts present themselves can be understood as follows. Overseas producers, which are dependent on maritime shipping to deliver their goods, and land producers (domestic producers and overland importers) compete in the market. A bunker price increase raises the cost of shipping, increasing the costs of overseas but not land producers. The changed competitive position of overseas and overland producers causes market shares to shift between them. The higher cost of supply pushes up the price of the good and, in response, the quantity demanded decreases; the size of the price increase depends on the extent to which firms are able to pass on the increased costs, which depends both on competitive conditions and the sensitivity of consumer demand to prices. Figure 2 depicts these interactions.

Figure 2 The assessment framework captures many market interactions



Source: Vivid Economics

The distribution and magnitude of impacts can be described and often estimated. The costs of the scheme are borne by consumers, ship owners and overseas producers (who face costs due to both a loss of quantity sold, and a reduction in profit margin). Those who gain from the scheme are the beneficiaries of any revenues raised (through auctioning or taxation), and land-based producers, who gain both in terms of market share and profit margin.

As the examples explored in this report illustrate, the factors that determine the overall impacts of bunker price increases on individual product markets can be summarised as:

- the way in which freight rates respond to increased bunker price;
- the share of maritime freight costs in product prices (in turn dependent on distance and efficiency of transport); and
- the ability of importers to pass on costs to local consumers.

In turn, the factors that determine cost pass-through rates are:

- the share of imports in consumption; and
- competitiveness of local markets and imports.

The steps of the analysis for each market are as follows:

- determine the sensitivity of relevant freight rates to a change in the bunker price. This sensitivity is captured by the *elasticity* of the freight rate with respect to the bunker price. This is the percentage change in the freight rate which results from a 1 per cent increase in the bunker price. In this report, this is derived through original econometric analysis rather than the literature;
- estimate the increase in freight rates from an increase in the bunker price;
- compile data on the prices, quantities sold and market shares of both domestic producers and importers in the relevant market; and
- estimate the potential impacts of imposing an additional cost on sea-based, but not land-based producers, including cost pass-through, overall changes in price and quantity demanded, and changes in market share.

The final step is achieved by means of an economic model, based on the standard Cournot model, for two of the products examined, iron ore and crude oil. Where time has not allowed the use of the detailed model, impacts have been estimated through simple accounting formulae, and cost pass-through has been judged based on previous experience of using the economic model.

Two econometric models are used to estimate freight rate elasticities. Details of these models are described in Annex 3. The first of these, Ordinary Least Squares (OLS), is the simplest and most commonly used econometric model. The OLS estimation technique uses explanatory variables, such as the bunker price, to explain changes in the absolute level of the freight rate. In contrast, the Error Correction Model (ECM) estimation uses combinations of the explanatory variables to explain *changes* in the freight rate. This latter method can be more accurate where the variables have dynamic behaviour which is linked in a specific manner.[2]

In this study, the ECM is generally to be preferred to the OLS estimate. However, it is not used for the container route and VLCC data. For containers, this is because the data are only available on a quarterly basis (as opposed to weekly for all other ship types), which is insufficient for the ECM analysis. For VLCCs, it is due to

[2] The statistical term for this is when the dynamic process governing the evolution of these variables is characterised by a unit root.

inconsistencies in units between years. Otherwise, results for both models are presented. Data are taken from Clarksons and UNCTAD. Freight rate data for the routes in the product market analyses are not always available but, because there is a high level of correlation between freight rates for different routes and for most ship types, elasticities derived for the shipping routes for which there is data can be used as indicative of other routes. Nonetheless, consideration should be given to any possible idiosyncrasies when applying estimated elasticities to other routes.

1.3 Report structure

Sections 2 to 5 contain discussion of each of the example products in turn. The first part of each section sets out the evidence on the elasticity, while the latter part focuses on economic impacts. Section 6 presents the conclusions. There are several Annexes to the report. Annex 1 lists the scope of work of the study. Annex 2 contains further detailed charts and results. Annex 3 offers detail on the econometric modelling.

2 Iron ore

Key messages

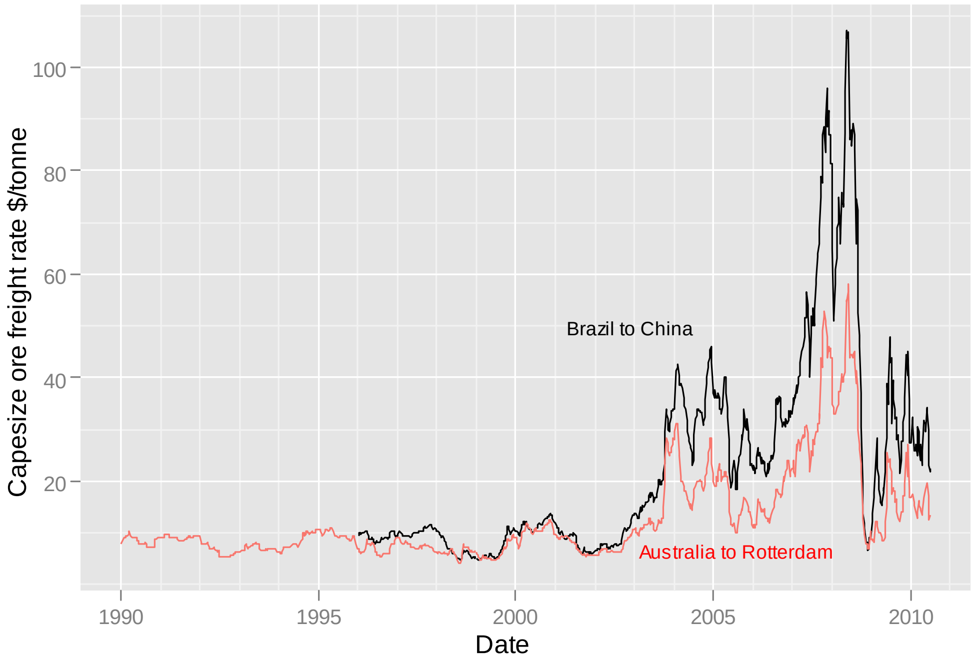
- China derives about half of the iron content of the ore it consumes from sea-borne imports.
- The elasticity of freight rates with respect to the bunker price for iron ore shipping is the highest of all the product markets examined here, at close to unity. A given percentage increase in bunker price results in an almost identical percentage increase in freight rates.
- Of all products examined, iron ore is the bulk commodity with the lowest value to weight ratio, and hence the highest average freight rate on an *ad valorem* basis.
- These two factors combine to give the highest price change of all the product markets examined from a 10 per cent increase in the bunker price, at around 1.5 per cent.
- This, along with a moderate cost pass-through of 52 to 59 per cent, induces a greater impact on overseas exporters than in the other product markets.
- Smaller Chinese producers may expand production as their margins increase due to the increase in the price of the good.
- The effects on exporting countries depend on their distance from China and the efficiency (size) of their firms. Australia sees relatively little impact due to its proximity and large, low cost firms. Brazil sees a lesser impact than India, despite its greater distance, due to the fragmented nature of Indian iron ore exports to China.
- Overseas firms which lose market share in China would find themselves advantaged in markets closer to their own countries, as well as domestically; consolidation may be stimulated in countries with many smaller firms.

2.1 The effect of bunker price increases on iron ore freight rates

2.1.1 There has been considerable volatility in iron ore freight rates over the past seven years

Figure 3 shows recent Capesize ore freight rates for Brazil to China and Australia to Rotterdam. For both routes, freight rates experienced a general upward trend, with considerable volatility, between 2002 and 2008, followed by a sudden drop. Prices are highly correlated across these two markets, suggesting that they belong to the same (global) shipping market. The chart indicates that incidental changes in freight rates are likely to be much larger, if recent patterns persist, than any increase brought about by a market-based measure.

Figure 3 Volatility in spot iron ore freight rates has increased over the last 20 years, nominal prices



Source: Vivid Economics and Clarksons data

2.1.2 *Adjusted for metal content, freight rates from Australia to China are substantially lower than for other countries*

Table 1 presents the freight rates for iron ore from various overseas exporters to China. The freight rates are also shown adjusted for the metal content of the ore. Australian iron ore is at least 20 per cent cheaper on a gross weight basis to transport to China than ore from other countries, and adjusted for metal content, it is 18 per cent cheaper.

Table 1 The transport of iron ore from Australia to China is much cheaper than for other importers

Importer	Freight rate to China ($ per tonne, 2005 to 2007 average)	Metal content of ore (%)	Implied freight rate ($ per tonne of metal)
Australia	16.3	62.5	26.0
Brazil	38.8	65.9	58.9
China	-	32.9	-
India	20.2	64.0	31.5
Iran	22 (assumed)	48.2	45.6
Rest of the World	35 (assumed)	58.9	59.4
South Africa	27.1	63.2	42.9

Source: Vivid Economics calculations using data from Clarksons and the US Geological Survey

2.1.3 *Iron ore freight rates are sensitive to bunker price increases, particularly on routes to China*

Table 2 lists estimates for the elasticity of freight rates with respect to bunker price for 11 Capesize routes for which data are available.

A 1 per cent increase in bunker price causes freight rates to increase by 6 to 14 per cent. This is the most bunker price-sensitive freight rate of any of those estimated in this report. There is also a considerable variation in the elasticities between routes; for example, the estimate of the elasticity is high on many routes originating in Brazil. There are many different factors which may influence variation in freight rate elasticity, and these are discussed more fully in section 6.

For iron ore, as for the other shipping markets, we have presented an average estimate of the elasticity. This estimate is a simple arithmetic average of the individual route estimates,[3] and is designed to give an overall view of the sensitivity of the freight rate to bunker price in that shipping segment. It may be that there is a single global elasticity and that the variation between routes is due to fluctuations in the data, or it may be that the elasticity differs systematically between routes and it is strictly incorrect to present a global average. The presentation of a global average is not meant to imply that there is in fact a single global figure: it is presented for convenience.

[3] This is why no standard error is presented for the average.

A freight rate elasticity of 0.96, the simple average of the ECM estimates in table 2, is used for the quantitative analysis below.

Table 2 Iron ore freight rates increase by 9.6 per cent for a 10 per cent increase in bunker price

Origin	Destination	Data availability	Elasticity estimate OLS	Elasticity estimate ECM
Narvik (Norway)	Rotterdam (EU)	1990–2010	0.635 (0.038)	0.801 (0.282)
Tubarao (Brazil)	Rotterdam	1991–2010	0.934 (0.044)	1.139 (0.312)
Tubarao	Japan	1991–2010	1.074 (0.046)	1.307 (0.354)
Tubarao	Beilun (China)	1996–2010	1.031 (0.059)	1.373 (0.381)
Nouadhibou (Mauritania)	Rotterdam	1990–2010	0.644 (0.037)	0.577 (0.255)
W. Australia	Rotterdam	1990–2010	0.623 (0.035)	0.483 (0.281)
W. Australia	Japan	1990–2010	0.716 (0.039)	0.717 (0.325)
Saldanha Bay (South Africa)	Beilun	2001–2010	0.828 (0.097)	0.804 (0.608)
W. Australia	Beilun	2001–2010	0.759 (0.101)	1.165 (0.627)
Goa (India)	Beilun	2001–2010	0.853 (0.093)	0.829 (0.540)
Port Cartier (Quebec)	Rotterdam	2001–2010	0.701 (0.098)	1.358 (0.494)
Average			0.800	**0.959**

Source: Vivid Economics and Clarksons data. Figures in brackets are standard errors.

2.2 Description of the iron ore market in China

Chinese consumption of iron ore is in the region of 900 Mt per annum.[4,5] By gross weight, most of the iron ore is from domestic sources. Australia, India and Brazil, the world's top three producers after China, are the most important importers, each supplying between 8 and 15 per cent.

Figure 4 shows the market share by producer country, both in terms of gross weight (top figure) and metal content (bottom figure). Chinese iron ore is much lower in metal content than that of the major importers (33 per cent compared with 63–66 per cent). By metal content, the market share of domestic ore is around half, with the big three importers almost making up the other half. The metal content figures show the true dependence on imports and are used throughout the rest of the analysis in Section 2.

Approximately two-thirds of Chinese domestic production is by state-owned or part state-owned enterprises (US Geological Survey, 2007), of which there are eight large enterprises. Most of these are vertically integrated and produce steel. Consequently, a great deal of the iron ore mined in China is transferred between associated companies and is not traded in the market (Wiley Rein, 2006). In India, another large supplier to China, two large state-owned enterprises are active but, in contrast to the other major importing countries, no company (state-owned or private) controls more than 20 per cent of production and there are a large number of small producers.

The world's three largest iron ore producers, Rio Tinto, BHP Billiton and Vale, are estimated to account for about a third of the Chinese market and half of imports.[6] They also account for 30 to 67 per cent of output each in their main countries of operation (Australia for Rio Tinto and BHP Billiton, and Brazil for Vale). Rio Tinto and BHP Billiton have recently agreed to combine their Western Australia

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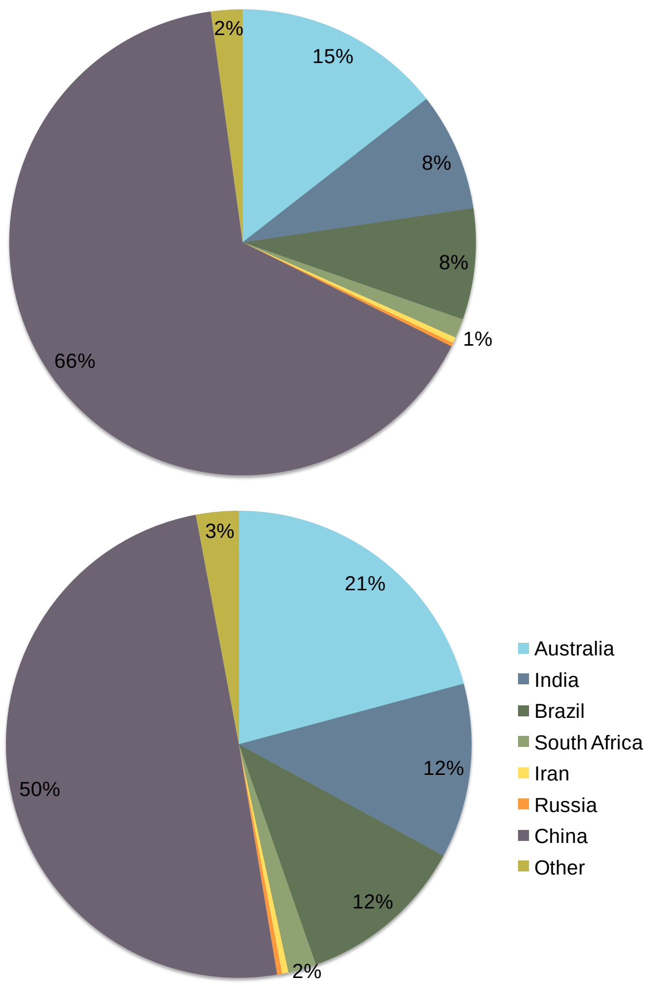
[4] Derived from UNSD COMTRADE and US Geological Survey data. Some data components are available only up to 2007.

[5] For the purpose of simplification, all data presented is for non-agglomerated iron ore only. This makes up 95% of Chinese imports.

[6] Note that due to a lack of data on the destination of output from individual mines and companies, these estimates are based on the proportion of exports to China in the companies' mines' countries of operation.

operations into a 50:50 owned joint venture (BHP Billiton, 2009). This single joint venture would supply a quarter of Chinese demand if current provenance patterns persist.

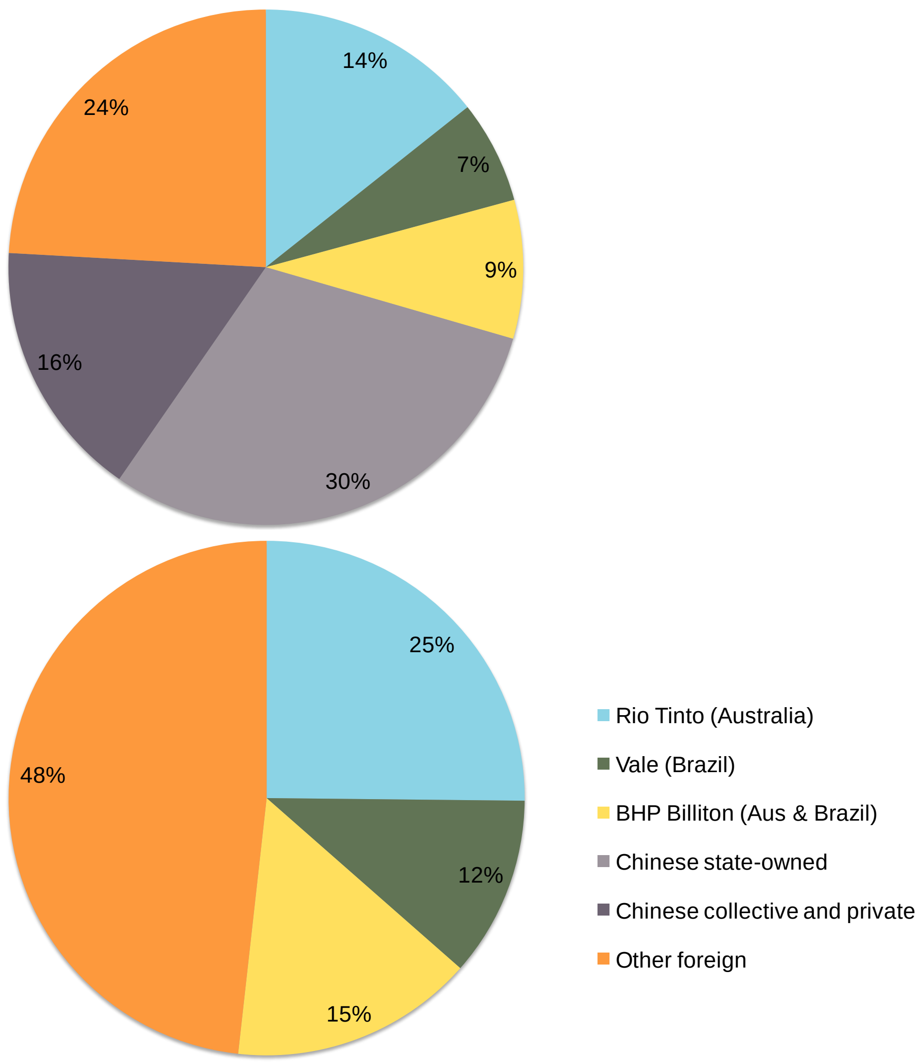
Figure 4 Domestic production of iron ore measured by metal content accounts for about half of consumption of that in China



Source: UNSD COMTRADE database, US Geological Survey and Vivid Economics calculations. Note: figures are the average for 2005-7; (top) gross weight and (bottom) metal content.

World iron ore prices increased five-fold between 2000 and 2008, partly due to surging demand in China (UNCTAD, 2009). Long-term contracts have been the norm in the iron ore market until recently. The tendency now is for shorter term contracts and the spot market has become increasingly important. Around half of global iron ore sales are on a spot market basis (International Mining, 2010). The spot price has recently been well above the long-term contract price. The trend is also for prices, until recently led by a negotiated 'benchmarking' system, to become more flexible and market-based (Economist, 2009).

Figure 5 Three iron ore mining companies may make up around half of exports to China



Source: InfoMine, UNSD COMTRADE database, US Geological Survey and Vivid Economics calculations. Note: (top) Chinese market overall (bottom) imports, metal content.

2.3 The effect of bunker price increases on the iron ore market in China

2.3.1 The links between domestic iron ore and steel production suggest two different configurations of the economic model

The analysis presented here uses two versions of the economic model: version one treats all domestic and imported ore as available for sale to any company in China; version two excludes output from state-owned enterprises, given that much of their output may be allocated internally rather than traded.

2.3.2 A 10 per cent increase in bunker fuel price increases domestic producers' market share by about 14-18 per cent

An increase of 10 per cent in the bunker fuel price, used in conjunction with a freight rate elasticity of 0.96, might stimulate a significant increase in the market share of domestic producers, perhaps of the order of 14-18 percentage points, in the model. There is a corresponding drop in the market share for sea-borne imports into China, for both model versions. The increase in share of land-based exporters, such as Russia, is negligible. A summary of the main model results is listed in table 3.

Table 3 A 14 to 18 per cent drop in importers' market share might follow a 10 per cent increase in bunker price

	Spot market including Chinese SOEs			Spot market excluding Chinese SOEs		
	Initial	Final	Change	Initial	Final	Change
Market Size (million tonnes p.a.)	412.3	407.7	-1.13%	289.0	285.4	-1.3%
Price ($ per tonne)	111.9	113.5	1.42%	111.9	113.7	1.6%
Domestic market share	46.0%	59.6%	13.6%	23.0%	40.8%	17.81%
Land-based market share	46.3%	60.2%	13.9%	23.4%	41.7%	18.3%
Sea-based import market share	53.7%	39.8%	-13.9%	76.6%	58.3%	-18.3%
Average added cost for sea importers ($ per tonne)		3.07			3.04	
Cost pass-through for sea importers		51.7%			58.7%	

Source: Vivid Economics calculations

The increase in Chinese production could occur if small privately owned mines increase output aggressively. This is plausible if the rise in price improves their competitive position significantly compared with their initial, low profit margins. If small Chinese firms were unable to expand output, or if control of iron ore production in China were less diffuse than is presumed, then the impact on foreign producers would be lower.

The best estimate of cost pass-through is 52 per cent where Chinese state-owned enterprises are included, and 59 per cent in the scenario where they are excluded. The price might rise by 1.4 to 1.6 per cent, with a corresponding decrease in the quantity of ore imported.

2.3.3 *More distant producers and countries with more numerous, smaller producers, endure the greatest falls in export sales*

There is a more detailed picture available and table 4 lists the change in market share and profit margin country by country. Of all the importers, Australia experiences the smallest impact, due to its relative proximity and the scale and low cost of its two major mining companies. In contrast, although India faces only slightly higher freight rates, its smaller, higher cost firms cause it to lose greater market share than the more distant Brazil, with the bulk of production accounted for by a single large, low-cost firm, Vale. Those parts of the world where firms have little market share and low margins could cease exporting to China.

When Chinese state-owned enterprises are excluded from the model, similar changes in market share are obtained, but the changes in exporters' profit margins are smaller. With the exclusion of the state-owned enterprises, foreign firms have a larger market share and so are better able to pass through increased costs to Chinese consumers of iron ore. This leads to a higher rise in the Chinese iron ore price for a given increase in shipping costs than when the state-owned enterprises participate in the spot market and, therefore, a smaller reduction in profit margins. There is a counteracting effect, however, which is that the market share loss by foreign producers is larger in this case, because the competitive position of smaller mines is stronger as they account for a larger share of the spot market once the output of the state-owned enterprises is excluded.

Table 4 Foreign producers with smaller market shares and longer shipping routes experience greater falls in volume of sales

	Spot market including Chinese state-owned enterprises			Spot market excluding Chinese state-owned enterprises		
	Original market share	Change in market share in percentage points	Change in margin ($ per tonne of metal)	Original market share	Change in market share in percentage points	Change in margin ($ per tonne of metal)
Australia	29.4%	-0.9%	-0.9	42.0%	-0.9%	-0.7
Brazil	8.3%	-2.4%	-4.1	11.9%	-3.3%	-3.8
China	46.0%	+13.6%	+1.6	23.0%	+17.8%	+1.8
India	11.2%	-6.5%	-1.4	16.0%	-8.4%	-1.2
Iran	0.4%	-0.4%	-2.8	0.6%	-0.6%	-2.6
Rest of the World	2.7%	-2.7%	-4.1	3.9%	-3.9%	-3.9
South Africa	1.6%	-0.9%	-2.7	2.3%	-1.2%	-2.4

Source: Vivid Economics calculation

2.3.4 *The results are medium-term equilibrium outcomes*

These results indicate outcomes in the medium term if market conditions remain unchanged except for the increase in bunker price. If the Chinese market for iron ore continues to grow, then overseas producers' sales might grow and offset the effect of bunker price increases. For example, in the scenario where state-owned firms are excluded from the spot market, Brazil's exports to China could return to their initial levels if demand in China grows by around twenty per cent.

In addition, both firms and policy-makers in exporter countries might react to changes in market conditions. For example, Indian firms may respond by consolidating and achieving lower unit costs. Alternatively, India might alter its fiscal policy. It recently raised its iron ore export tax from 10 to 15 per cent (an increase of around $5 per tonne, compared to loss in profit margins suggested by the model of ~$1 per tonne); such policies might be reviewed.

While Indian firms might find exports to China less profitable, they could also be in a stronger competitive position in the domestic market, as well as closer export markets such as the Middle East. Increased sales in such markets might compensate somewhat for reduced exports to China.

3 Crude oil

Key messages

— South Korea is entirely dependent on sea-borne imports, particularly from the Middle East. In contrast, the US ships from overseas half of the oil it consumes.

— VLCC freight rates are moderately sensitive to bunker price changes, generally increasing by 3–4 per cent if the bunker price increases by 10 per cent.

— Cost pass-through in the South Korean market is over 100 per cent, and is around 73 per cent in the US market.

— Oil price increases are 0.1 per cent or less and changes in market share are of similar size. This is because crude oil is a high value product compared to its freight costs.

3.1 The effect of bunker price increases on crude oil freight rates

3.1.1 VLCC rates are moderately sensitive to bunker price increases

Table 5 presents estimates of the elasticity of VLCC freight rates with respect to bunker price.[7] One commentator suggests that the elasticity of the VLCC freight rate with respect to bunker price may be higher at higher bunker prices.[8] His argument is that some vessels engage in slow-steaming at times of high bunker price, which reduces the volume of crude that can be moved for a given number of vessels. In order to account for this possible effect, an additional statistical model was tested in which the elasticity may increase with bunker price. There was little difference in the estimates from the two models.

On most routes, a 10 per cent increase in bunker price is expected to increase freight rates by 2–5 per cent. The estimated elasticity is fairly consistent across routes, although it is lower on the routes originating from Bonny Offshore and Sidi Kerir. The elasticity used in the quantitative analysis below is 0.4, reflecting estimates for routes into South Korea and the US Gulf.

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[7] Note that because of the nature of the data it was not possible to run the ECM model for VLCCs.

[8] Devanney, J., *The Impact of Bunker Price on VLCC Spot Rates*, Martingale Inc.

Table 5 VLCC freight rates generally increase by 3–4 per cent if bunker price increases by 10 per cent

Origin	Destination	Data availability	Elasticity estimate	
			Constant elasticity	Variable elasticity
Ras Tanura (Saudi Arabia)	Rotterdam (Netherlands)	1990–2010	0.331 (0.079)	0.247 (0.380)
Ras Tanura	Ulsan (South Korea)	1990–2010	0.399 (0.097)	0.357 (0.488)
Ras Tanura	Chiba (Japan)	1990–2010	0.385 (0.096)	0.321 (0.455)
Ras Tanura	Loop (US Gulf)	1997–2010	0.463 (0.124)	0.463 (0.650)
Bonny Offshore (Nigeria)	Loop	1997–2010	0.342 (0.121)	0.292 (0.376)
Bonny Offshore	Kaohsiung (Taiwan)	1998–2010	0.249 (0.122)	0.123 (0.145)
Ras Tanura	Ain Sukhna (Egypt)	1990–2010	0.364 (0.100)	0.345 (0.451)
Sidi Kerir (Egypt)	Rotterdam	1990–2010	0.236 (0.074)	0.158 (0.224)
Ras Tanura	Singapore	1996–2010	0.534 (0.139)	0.606 (0.795)
Average			0.367	0.324

Source: Vivid Economics and Clarksons data. Figures in brackets are standard errors.

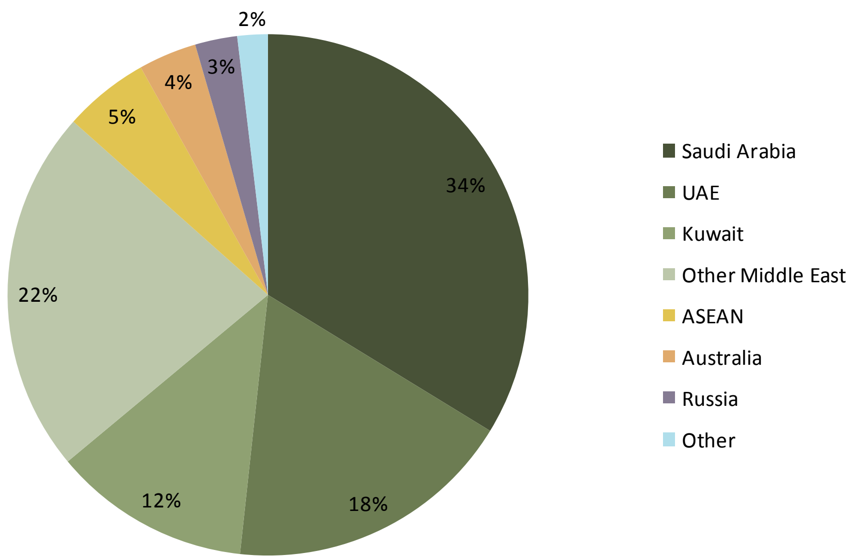
3.2 Description of the South Korean and US crude oil markets

3.2.1 South Korea is heavily dependent on Middle Eastern oil

Figure 6 shows South Korean imports of crude oil by origin. It has no oil production of its own and is the fifth largest net oil importer in the world. Thus the Middle East to South Korea route is an important crude oil route.

Eighty-seven per cent of the oil is imported from the Middle East, and Saudi Arabia in particular, with a small share from Russia, Australia, the ASEAN bloc and other countries.

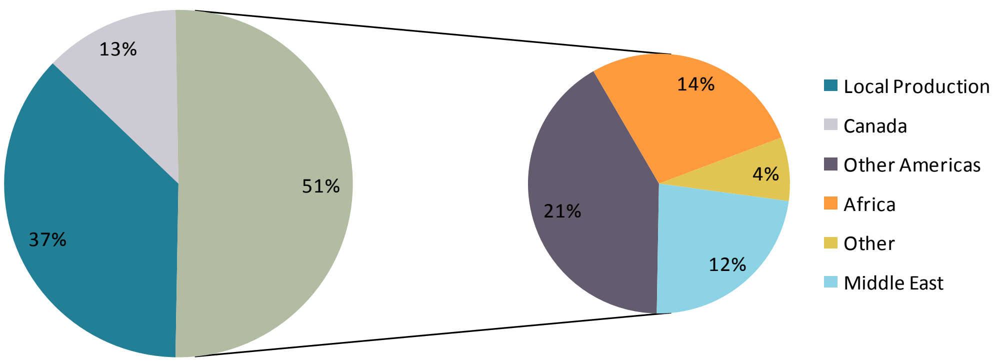
Figure 6 Middle Eastern imports account for 87 per cent of South Korea's crude oil consumption



Source: UNCTAD/WTO and US Energy Information Administration

These figures can be compared with those of the US in figure 7. Around half of oil consumed in the US is imported by sea, with 37 per cent from domestic production and the remaining 13 percent by pipeline from Canada. The rest of the Americas and Africa are larger exporters to the US than is the Middle East.

Figure 7 Sea-borne imports account for only a half of US oil consumption



Source: UNCTAD/WTO and US Energy Information Administration

3.3 The effect of bunker price increases on selected crude oil markets

3.3.1 Two scenarios of the model are run for each market to account for variation in the oil price

The economic model is calibrated to the most recent year for which trade data are available: 2008 in the case of South Korea, and 2009 in the case of the US. In 2008, the average crude price was $95/barrel ($696/tonne), while in 2009 it was $60/barrel ($440/tonne). For the sake of comparison, the model is run for both markets at each price. Each country is represented in the model as a single firm, implying that each producing country controls the volume of oil it exports.

3.3.2 The South Korean oil price rises by less than 0.2 per cent

Table 6 presents a summary of the model results for the two scenarios for the South Korean market. The transport cost, at $17–25 per tonne, on an *ad valorem* basis is 2.4–5.7 per cent. Costs for sea importers increase by $0.69/tonne, or less than 0.2 per cent, and they can pass these costs through to customers since South Korea has high dependency on sea-borne imports. The resultant change in price facing consumers is less than 0.2 per cent.

Table 6 The effect of a 10 per cent increase in bunker price on the South Korean crude oil market is very small

	Oil price $95 per barrel			Oil price $60 per barrel		
	Initial	**Final**	**Change**	**Initial**	**Final**	**Change**
Market Size (million tonnes p.a.)	116.7	116.7	-0.02%	116.7	116.7	-0.03%
Price ($ per tonne)	696.6	697.4	0.11%	440.0	440.7	0.17%
Domestic market share	0.0%	0.0%	0.00%	0.0%	0.0%	0.00%
Land-based market share	0.0%	0.0%	0.00%	0.0%	0.0%	0.00%
Sea-based import market share	100%	100%	0.00%	100%	100%	0.00%
Average added cost for sea importers ($ per tonne)		0.69			0.69	
Cost pass-through for sea importers		111%			112%	

Source: Vivid Economics calculations

The high concentration of supply into South Korea might give suppliers a degree of pricing power such that prices are set at a slight mark-up to costs. This would be consistent with a cost pass-through rate above 100 per cent.

3.3.3 There is lower cost pass–through in the US market

Table 7 lists results for the US market. The changes in price and quantity are smaller than for South Korea. This is because competition from domestic and land importers limits cost pass-through to around 73 per cent and because the average freight cost increase for sea importers, which is well below 0.1 per cent of the value of the product, is also smaller due to the relative geographical proximity of suppppliers.

Table 7 A 10 per cent increase in bunker price results in a negligible change in sea-borne imports in the US

	Oil price $95 per barrel			Oil price $60 per barrel		
	Initial	**Final**	**Change**	**Initial**	**Final**	**Change**
Market Size (million tonnes p.a.)	742.8	742.8	-0.01%	742.8	742.8	-0.01%
Price ($ per tonne)	696.6	696.8	0.03%	440.0	440.2	0.04%
Domestic market share	36.9%	37.0%	0.03%	36.9%	37.0%	0.06%
Land-based market share	49.5%	49.5%	0.04%	49.5%	49.5%	0.08%
Sea-based import market share	50.5%	50.5%	-0.04%	50.5%	50.5%	-0.08%
Average added cost for sea importers ($ per tonne)		0.24			0.24	
Cost pass-through for sea importers		72.6%			73.4%	

Source: Vivid Economics calculations

Table 8 sets out the changes in market share and profit margin for producers by region. Domestic producers might gain some market share, and the Middle East, as the most distant and smallest major supplier, might lose some market share. Other regions experience virtually no change in market share, although do lose some sales.

Table 8 Most of the reduction in sea-borne import market share is borne by the Middle East

	Original market share	Change in market share in percentage points	Change in sales in the US	Change in margin ($/tonne)
US	36.9%	0.0	0.2%	0.2
Canada	12.5%	0.0	0.2%	0.2
Other Americas	20.9%	0.0	0.1%	0.1
Middle East	11.7%	-0.0	-0.6%	-0.3
Africa	13.9%	-0.0	-0.2%	-0.1
Other	4.0%	-0.0	-0.3%	0.0

Source: Vivid Economics calculations

4 Grain

Key messages

— Developing country grain markets vary hugely in their dependence on overseas imports; some, such as the Saudi Arabian maize market are almost entirely dependent on imports, while others, such as the Philippine rice market, import only one sixth of the total volume consumed.

— Panamax grain freight rates are relatively insensitive to bunker price changes, increasing by about 2.5 per cent in response to a 10 per cent bunker price increase.

— Price increases in grain markets following a 10 per cent bunker price increase are 0.7 per cent or less, even in cases of high import dependence, and despite freight rates which are frequently 20 per cent or more of product value.

— Cost pass-through rates might range from 5 per cent to 100 per cent. In most cases, most of the cost of bunker price increases is borne by domestic consumers. Developed world grain producers bear most of the cost only in those cases where share of imports in the destination market is small and where these imports almost exclusively originate from the developed world (see section 4.2.5).

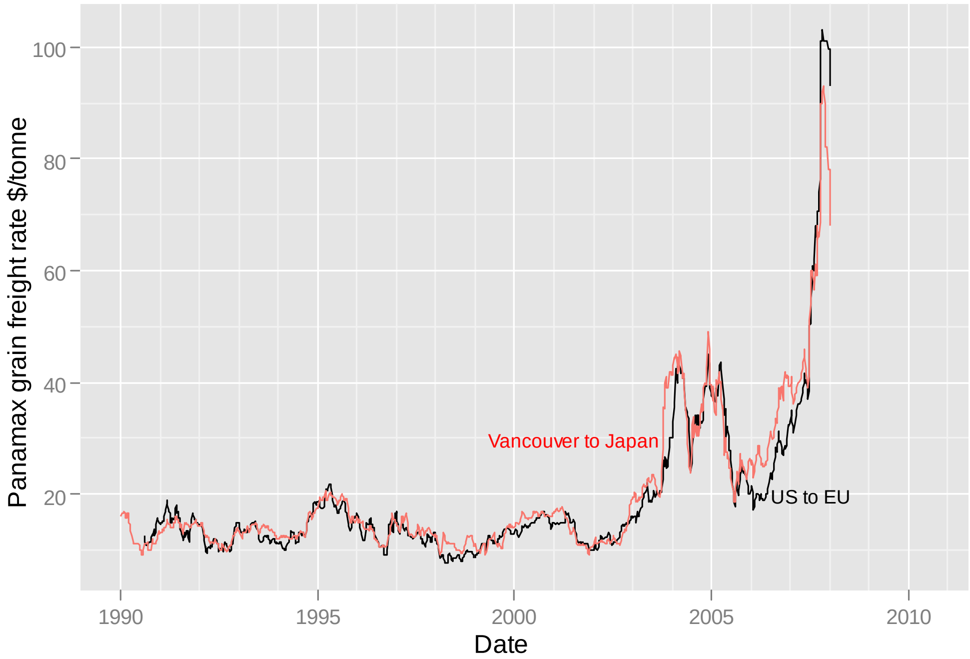
4.1 The effect of bunker price increases on grain freight rates

4.1.1 The past decade saw massive increases in grain freight rates

Figure 8 shows recent Panamax grain freight rates for two routes, Vancouver to Japan and US to EU. There are two points to note from this chart. Firstly, freight rates for the two routes appear to be highly correlated: vessels can generally carry cargo on any number of global routes, so increased demand on a subset of routes will push up prices for all routes.

Second, the freight rate history matches some, but not all, of the features of the bunker price history shown in Figure 8, including a general upward trend from 2000. The peak in freight rates slightly precedes that for bunker price and appears to have coincided with a general sharp rise in world food prices. Changes in freight rates due to the dynamics of the global grain market appear likely to dwarf any increases due to a market-based mechanism for regulating emissions.

Figure 8 Grain freight rates are highly correlated across routes



Source: Vivid Economics and Clarksons data

4.1.2 *Grain freight rates are relatively insensitive to bunker price increases*

Table 9 displays the estimated elasticities of freight rates with respect to bunker price for four Panamax and one Supramax grain route.

A 10 per cent increase in bunker price results in around a 2.5 per cent increase in grain freight rates for Panamax vessels. The single Supramax estimate is significantly higher. Sensitivity to bunker price is higher at higher bunker prices.

Table 9 Grain freight rates increase by 2.5 per cent when bunker price increases by 10 per cent on Panamax routes

Origin	Destination	Data availability	Elasticity estimate OLS	Elasticity estimate ECM
Panamax				
US Gulf[1]	Rotterdam	1990–2008	0.223 (0.039)	0.293 (0.218)
US Gulf[2]	Rotterdam	1990–2008	0.201 (0.039)	0.238 (0.224)
US Gulf[2]	Japan	1990–2008	0.218 (0.031)	0.156 (0.252)
Northern Pacific (US/Canada)[3]	Japan	1990–2008	0.103 (0.033)	0.314 (0.237)
Average			**0.186**	**0.250**
Supramax				
US Gulf[2]	Japan	2007–2010	1.430 (0.052)	1.561 (0.236)

Source: Vivid Economics and Clarksons data. Note: [1] Light grain; [2] Heavy grain, sorghums and soyas; [3] Unspecified. Figures in brackets are standard errors.

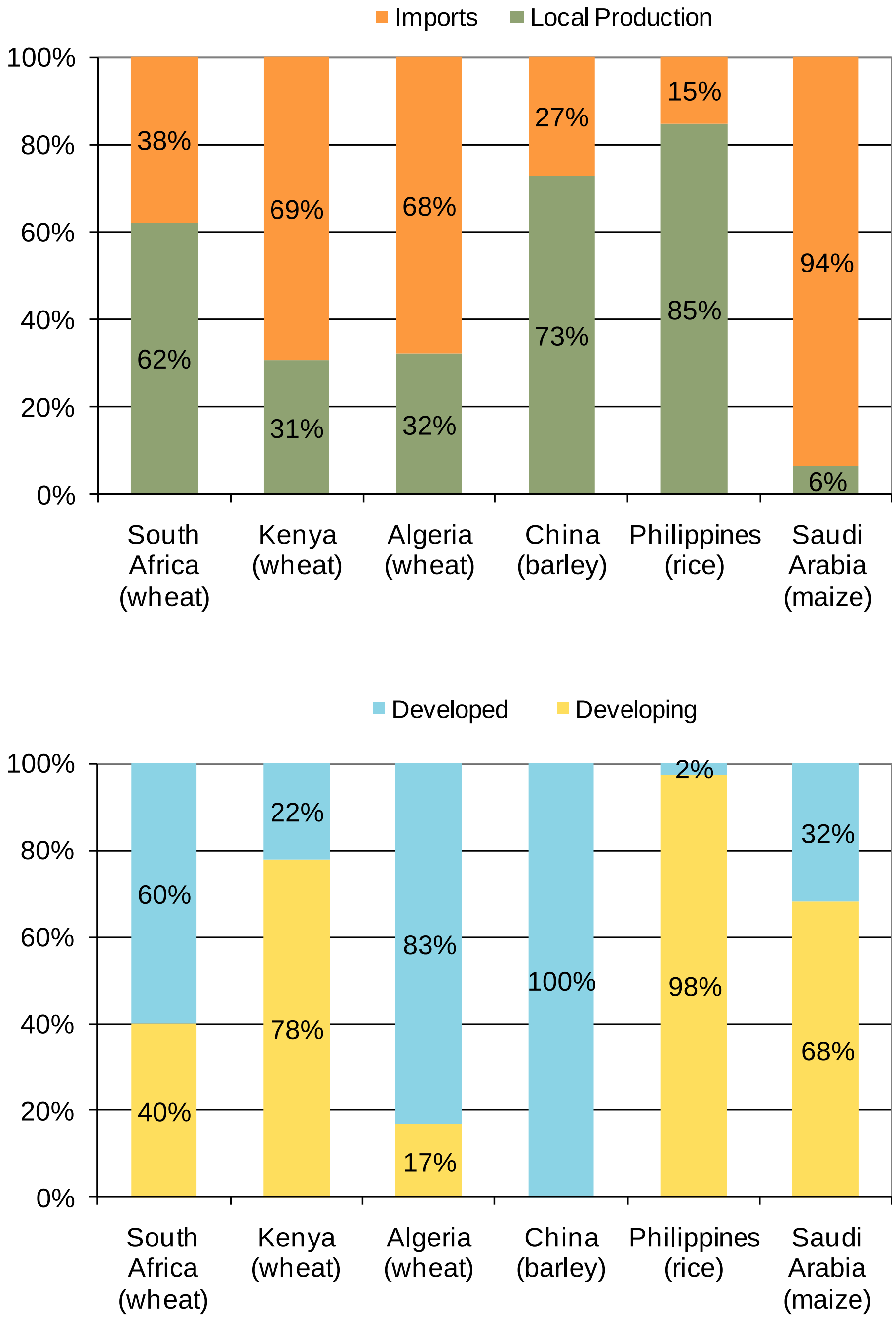
4.2 The effect of bunker price on grain markets

4.2.1 Six combinations of grains and countries are selected

Food prices are a concern for governments and people, particularly in lower-income countries. For this reason, the six destination markets selected for analysis are all developing countries. They exhibit a range of dependence on sea-borne imports, provenance of imports and length of principal sea routes. The routes supplying these countries encompass both developed and developing world exporters.

The six markets are wheat in South Africa, Kenya and Algeria; barley in China; rice in the Philippines and maize in Saudi Arabia. Figure 9 shows the share of imports and the split between developed and developing world suppliers for these six markets.

Figure 9 The selection of destination markets spans a range of dependency on sea-borne imports and developed/developing world producers



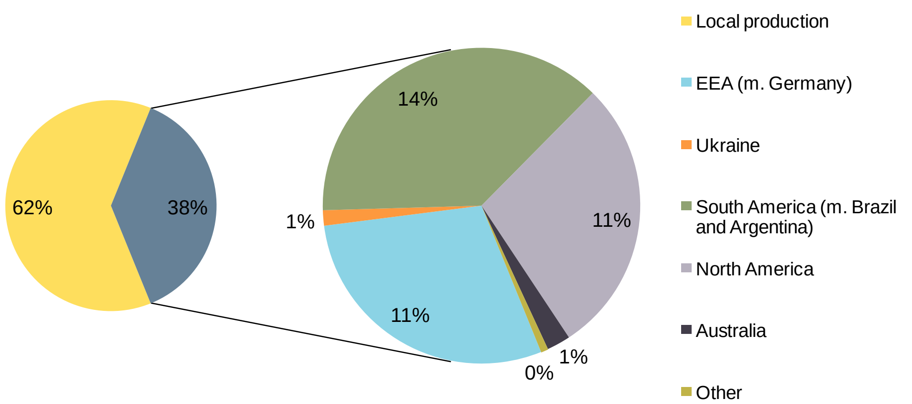
Source: International Trade Centre (UNCTAD/WTO)

Approximate estimates are made of the impacts of an increase in bunker price on freight rates. This is achieved by means of simple accounting relationships instead of a quantitative economic model. As a consequence, the changes in the market share of grain exporters[9] and rate of cost pass-through from freight rates to product prices are not calculated directly. Instead, the rate of cost-pass through is assumed based upon the particular market structure. The results are set out below.

4.2.2 *The wheat price in South Africa increases by no more than 0.2 per cent*

About 3 Mt of wheat is consumed in South Africa annually, of which about 2 Mt is grown domestically, as shown in figure 10. Germany, Argentina and the USA are the major foreign suppliers. The average profit margin of local producers is reported to be close to 50 per cent (Grain SA, 2010), suggesting that local producers are able to maintain high profit margins in the face of competition from imports.

Figure 10 Most wheat sold in South Africa is grown domestically



Source: UNCTAD/WTO and FAO

Table 10 presents some summary statistics for the market and an assessment of the potential impacts of a 10 per cent increase in the bunker price, using a freight rate elasticity of 0.25.

The freight rate increases by 2.5 per cent. Given the relatively low share of imports and the ability of domestic producers to maintain high profit margins, we assume

[9] The distribution of costs is based on the market share of importers *before* the bunker price increase. The approximate calculations used do not take account of the change in market share *after* the bunker price increase.

the cost pass-through rate is 10–40 per cent. This translates into a price change of less than a quarter of one per cent, and a smaller percentage reduction in quantity demanded.

Table 10 A 10 per cent rise in bunker price has a small effect on the South African wheat market

Element	Value
Initial price ($/tonne)	163–353
Initial total demand (mega-tonnes)	3.1
Market size ($m per annum)	505–1,094
Market share of sea-borne importers	38%
Freight rate: per tonne and *ad valorem*	from N America: $45 (21%) from S America: $43 (22%)
Elasticity of freight rates w.r.t. bunker price	0.25
Cost pass-through rate	10–40%
Increase in freight rates: per tonne and *ad valorem*	$1.1 (0.55%)
Resulting increase in price: per tonne and as %	$0.11–$0.44 (0.06–0.22%)
Reduction in demand due to price increase (kilo-tonnes and %)	1–3 (0.03–0.11%)
Cost to overseas producers from change in margin ($m)	1 – 1.4
Gain to land producers from change in margin ($m)	0.2 – 1.5
Cost to consumers from increase in price ($m)	0.28 – 2.4
Loss of consumer welfare from reduction in consumption	Negligible
Split in calculable producer cost between developed/developing	at most, developing world producers bear 27%
Split in calculable overall cost between developed/developing	46–64% of cost borne by developing world overall

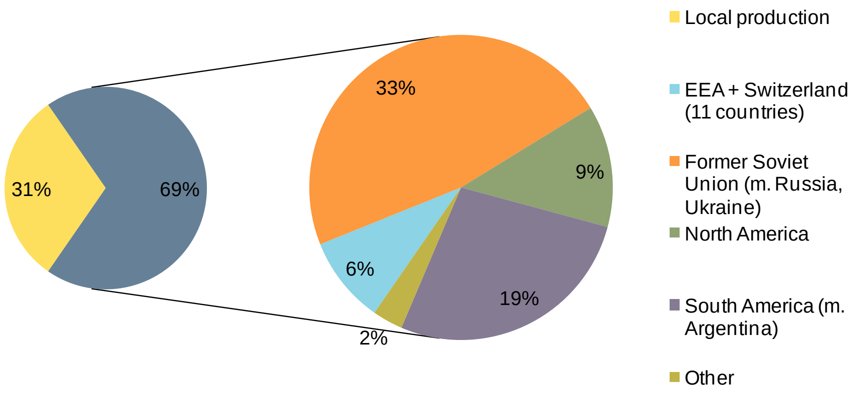
Source: Vivid Economics calculations based on FAO and OECD Maritime Transport Cost data

The overall cost to overseas producers is estimated at $1.4 million p.a. or less, while South African wheat producers are estimated to gain up to $1.5 million p.a. South African consumers might pay up to $2.4 million p.a. more for the wheat they consume. Around half of the costs imposed in the South African wheat market are borne by developed world producers, while the other half are borne by South African consumers.

4.2.3 *A larger increase in the wheat price might occur in Kenya*

About 1 Mt of wheat is consumed in Kenya annually, of which 69 per cent is imported. Argentina, Russia and Ukraine are the major suppliers, as shown in figure 11.

Figure 11 The Former Soviet Union alone supplies more wheat to Kenya than local producers



Source: UNCTAD/WTO and FAO

Table 11 presents some summary statistics and an assessment of the potential impacts of a 10% increase in the bunker price. The higher share of imports and high costs of local production (Nyangito et al., 2002) suggest that the cost pass-through rate might be higher, and we assume it to be around 50–75 per cent. This causes a price increase of 0.3–0.5 per cent.

We assume that importers are able to pass on more of their cost increase, and domestic producers consequently benefit from a higher price increase. The cost to Kenyan consumers from increased wheat prices might be up to $2 million p.a., but this is partially offset by a gain to Kenyan wheat producers of up to $0.6 million p.a. Overseas producers are estimated to be around $0.5 million p.a. worse off. Nearly all of the cost is borne in the developing world, as Kenya is mainly supplied by developing world producers.

Table 11 Kenya's greater reliance on sea-borne imports means proportionally higher impacts for consumers than in South Africa

Element	Value
Initial price ($/tonne)	240–425
Initial total demand (mega-tonnes)	1
Market size ($m per annum)	240–425
Market share of sea-borne importers	69%
Freight rate: per tonne and *ad valorem*	from Ukraine*: $30 (18%) from S America*: $42 (31%)
Elasticity of freight rates w.r.t. bunker price	0.25
Cost pass-through rate	50–75%
Increase in freight rates: per tonne and *ad valorem*	$0.9 (0.64%)
Resulting increase in price: per tonne and as %	$0.45–$0.68 (0.32–0.48%)
Reduction in demand due to price increase (kilo-tonnes and %)	1.6–2.4 (0.16–0.24%)
Cost to overseas producers from change in margin ($m)	0.5
Gain to land producers from change in margin ($m)	0.2 –0.6
Cost to consumers from increase in price ($m)	0.77 – 2.0
Loss of consumer welfare from reduction in consumption	negligible
Split in calculable producer cost between developed/developing	developing world producers bear at least 86% of small cost
Split in calculable overall cost between developed/developing	96–100% of cost borne by developing world overall

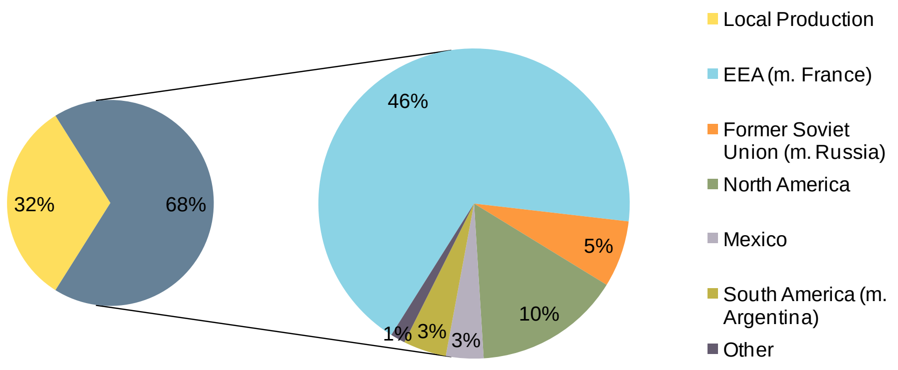
Source: Vivid Economics calculations based on FAO and OECD Maritime Transport Cost data.

Asterisks indicate inferred data based on routes covering a comparable distance.

4.2.4 *The Algerian wheat market has shorter average import sea routes, and this lessens the price increase experienced*

Algeria imports the same proportion of wheat as Kenya, but along shorter sea routes. About 7 Mt of wheat is consumed each year, of which about 5 Mt comes from France and Germany, as shown in figure 12. Other foreign suppliers include Canada, the US and the Former Soviet Union.

Figure 12 Most of Algeria's wheat comes from Europe



Source: UNCTAD/WTO and FAO

Table 12 presents summary statistics and the impacts of a 10% increase in the bunker price, as in previous sections. Again, a relatively high sea-borne import share of 68 per cent leads us to assume a cost pass-through rate of 50–75 per cent. However, this generates a smaller price increase, 0.2–0.3 per cent, than for Kenya, despite their other similarities, due to the share of imports which arrive via a shorter sea route.

The overall cost to overseas producers, mainly in the EU, is estimated at up to $2.5 million p.a., higher than in the Kenyan example, partly due to the smaller offsetting effect of increased prices, and partly due to the greater size of the market. The cost to Algerian consumers is greater, due to the size of the market, at up to $6.5 million p.a.. Developed world producers would bear costs while developing world producers would gain overall. However, once impacts on consumers are added, most of the total cost is likely to be borne in the developing world.

Table 12 Algeria's shorter sea import route gives rise to a lower impact on consumers than for Kenya

Element	Value
Initial price ($/tonne)	245–285
Initial total demand (mega-tonnes)	7.3
Market size ($m per annum)	1,789–2,081
Market share of sea-borne importers	68%
Freight rate: per tonne and *ad valorem*	from EU*: $20 (14%) from Americas: $45 (25%)
Elasticity of freight rates w.r.t. bunker price	0.25
Cost pass-through rate	50–75%
Increase in freight rates: per tonne and *ad valorem*	$0.66 (0.42%)
Resulting increase in price: per tonne and as %	$0.33–$0.49 (0.21–0.31%)
Reduction in demand due to price increase (kilo-tonnes and %)	8–11 (0.1–0.16%)
Cost to overseas producers from change in margin ($m)	1.5 – 2.5
Gain to land producers from change in margin ($m)	1.2 – 2.1
Cost to consumers from increase in price ($m)	3.7 – 6.5
Loss of consumer welfare from reduction in consumption	negligible
Split in calculable producer cost between developed/developing	gains to developing world producers overall developed world impact of $1-1.9 million
Split in calculable overall cost between developed/developing	65–84% of cost borne by developing world overall

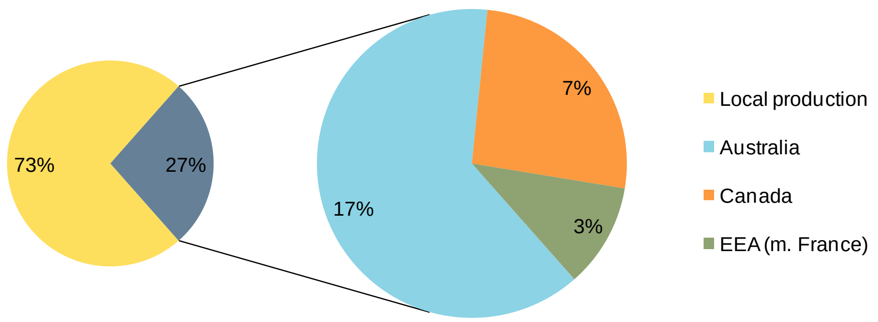
Source: Vivid Economics calculations based on FAO and OECD Maritime Transport Cost data.

Asterisks indicate inferred data based on routes covering a comparable distance.

4.2.5 *China's low dependence on barley imports limits domestic impacts*

The Chinese barley market is an example of a market which imports relatively little, only 27 per cent, of its supply but where imports are exclusively from developed countries. China is the largest importer of malting barley in the world, consuming about 4 Mt of barley, which may include barley for other uses, annually. Imported barley is considered to be of higher quality and is destined for use in premium beer manufacturing (FAL, 2007). As Figure 13 shows, Australia and Canada are the largest exporters.

Figure 13 China produces most of its own barley, with all imports originating from the developed world



Source: UNCTAD/WTO and FAO

Table 13 presents summary statistics and the potential impacts of the increase in the bunker price, as in previous sections. The low market share of imports suggests a low cost pass-through, perhaps of 10–25 per cent. However, if the market is segmented by quality, this could be significantly higher. A price change of 0.1 per cent or less might result.

The overall cost to overseas producers is estimated to be $0.8 million p.a. or less, while Chinese producers gain up to $0.7 million p.a. The cost to Chinese consumers is placed at up to $1 million p.a. from increased barley prices. The developed world would bear most of the overall cost.

Table 13 China's low dependence on imports results in small impacts on consumers and (overall) on producers

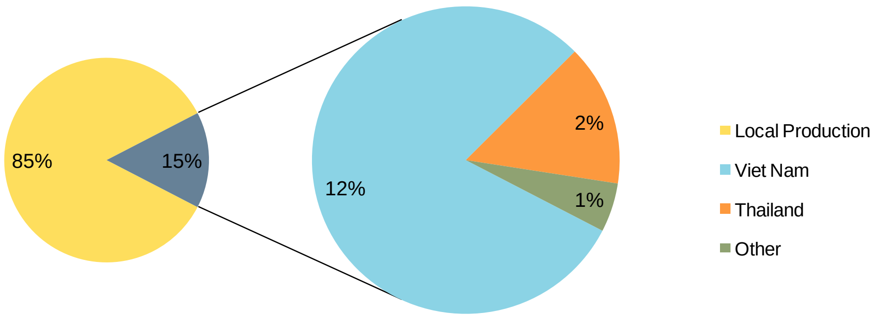
Element	Value
Initial price ($/tonne)	115–180
Initial total demand (mega-tonnes)	4.7
Market size ($m per annum)	541–846
Market share of sea-borne importers	27%
Freight rate: per tonne and *ad valorem*	from Australia: $30 (17%) from Canada: $56 (24%) from EU: $100 (43%)
Elasticity of freight rates w.r.t. bunker price	0.25
Cost pass-through rate	10–25%
Increase in freight rates: per tonne and *ad valorem*	$0.94 (0.48%)
Resulting increase in price: per tonne and as %	$0.09–$0.23 (0.05–0.12%)
Reduction in demand due to price increase (kilo-tonnes and %)	1–3 (0.02–0.06%)
Cost to overseas producers from change in margin ($m)	0.6 – 0.8
Gain to land producers from change in margin ($m)	0.2 – 0.7
Cost to consumers from increase in price ($m)	0.26 – 1
Loss of consumer welfare from reduction in consumption	Negligible
Split in calculable producer cost between developed/developing	gains to developing world producers developed world impact of $0.6-0.8 million
Split in calculable overall cost between developed/developing	10–25% of cost borne by developing world overall

Source: Vivid Economics calculations based on FAO and OECD Maritime Transport Cost data.

4.2.6 Philippine rice consumers are shielded by domestic production

Rice is a staple food in the Philippines, with about 12 Mt consumed annually. The Philippine government has pursued a policy of rice self-sufficiency for several years, partially through caps in imports (Dawe et al., 2006), resulting in a market share for importers of only 15 per cent and a price locally above world prices. Unsurprisingly, given the climatic conditions required for rice, all importers are developing countries, with almost all imports deriving from near-neighbours in South-East Asia, see figure 14.

Figure 14 The Philippines' small amount of imported rice is transported along short sea routes



Source: UNCTAD/WTO and FAO

Table 14 presents summary statistics and the potential impacts of an increase in the bunker price, as in previous sections. Given the low share of imports, the cost pass-through rate could be expected to be around 5-20 per cent. This rate is consistent with local producers having the capacity to expand production and take market share from importers. However, if there are practical constraints on production, and there is limited scope for further domestic price increases, then cost pass-through rate might turn out to be higher. As it is, the low cost pass-through rate suggested would result in a price increase of less than 0.05 per cent.

The overall cost to overseas producers is estimated at $0.7 million p.a. or less, while local producers gain by up to $1 million p.a. The cost to Philippine consumers is placed at up to $1.2 million p.a., a tiny fraction of the overall market size. The developing world would bear all of the net cost in this market.

Table 14 High domestic production and short sea import routes mute impacts on Philippino consumers from bunker price changes

Element	Value
Initial price ($/tonne)	163–244
Initial total demand (mega-tonnes)	11.8
Market size ($m per annum)	1,923–2,879
Market share of sea-borne importers	15%
Freight rate: per tonne and *ad valorem*	from SE Asia: $49 (7–10%)
Elasticity of freight rates w.r.t. bunker price	0.25
Cost pass-through rate	5–20%
Increase in freight rates: per tonne and *ad valorem*	$10 (0.21%)
Resulting increase in price: per tonne and as %	$0.05–$0.20 (0.01–0.04%)
Reduction in demand due to price increase (kilo-tonnes and %)	1–3
Cost to overseas producers from change in margin ($m)	0.6 – 0.7
Gain to land producers from change in margin ($m)	0.2 –1.0
Cost to consumers from increase in price ($m)	0.2 – 1.2
Loss of consumer welfare from reduction in consumption	negligible
Split in calculable producer cost between developed/developing	n/a, no developed world producers
Split in calculable overall cost between developed/developing	100% of cost borne by developing world

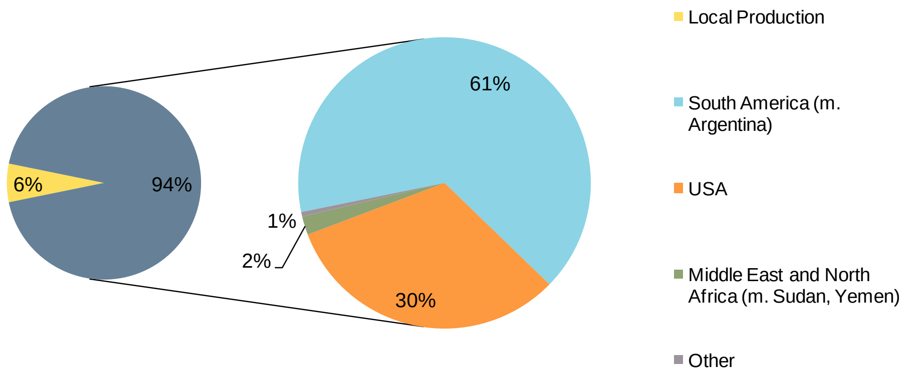
Source: Vivid Economics calculations based on FAO and OECD Maritime Transport Cost data.

Asterisks indicate inferred data based on routes covering a comparable distance.

4.2.7 Saudi Arabia's high sea import dependence generates the biggest consumer impacts

The Saudi Arabian maize market is an example of high dependence on relatively distant sea-borne importers. Around 2 Mt of maize is consumed annually in Saudi Arabia, of which 94 per cent is imported, 92 per cent by sea. Argentina and the USA are the major suppliers, with Argentina alone accounting for nearly two-thirds of total supply, see figure 15.

Figure 15 Saudi Arabia is highly dependent on distant importers for maize



Source: UNCTAD/WTO and FAO

Table 15 presents summary statistics and the potential impacts of a 10 per cent increase in the bunker price, as in previous sections. The high dependence on imports and the country's poor agricultural endowments suggest almost complete cost pass-through, resulting in a price increase of around 0.6 per cent. While this is the highest of the price increases estimated in this section, it remains much smaller than recent fluctuations in grain prices.

The cost to Saudi Arabian consumers is the greatest in proportion to market size of all the examples, at up to 0.7 per cent, or $2 million p.a.. Almost all of the cost would be borne by Saudi Arabian consumers and none by producers.

Table 15 The Saudi Arabian maize market experiences the greatest proportional consumer impact, with almost no impact on producers

Element	Value
Initial price ($/tonne)	196–225
Initial total demand (mega-tonnes)	1.4
Market size ($m per annum)	274–315
Market share of sea-borne importers	95%
Freight rate: per tonne and *ad valorem*	from USA: $49 (25%)
Elasticity of freight rates w.r.t. bunker price	0.25
Cost pass-through rate	90–100%
Increase in freight rates: per tonne and *ad valorem*	$1.23 (0.63%)
Resulting increase in price: per tonne and as %	$1.10–$1.23 (0.56–0.63%)
Reduction in demand due to price increase (kilo-tonnes and %)	3.9–4.4 (0.28–0.31%)
Cost to overseas producers from change in margin ($m)	0.0 – 0.2
Gain to land producers from change in margin ($m)	0.1
Cost to consumers from increase in price ($m)	1.54 – 2
Loss of consumer welfare from reduction in consumption	negligible
Split in calculable producer cost between developed/developing	at most, developing world producers bear 39% of small cost
Split in calculable overall cost between developed/developing	97–100% of cost borne by developing world overall

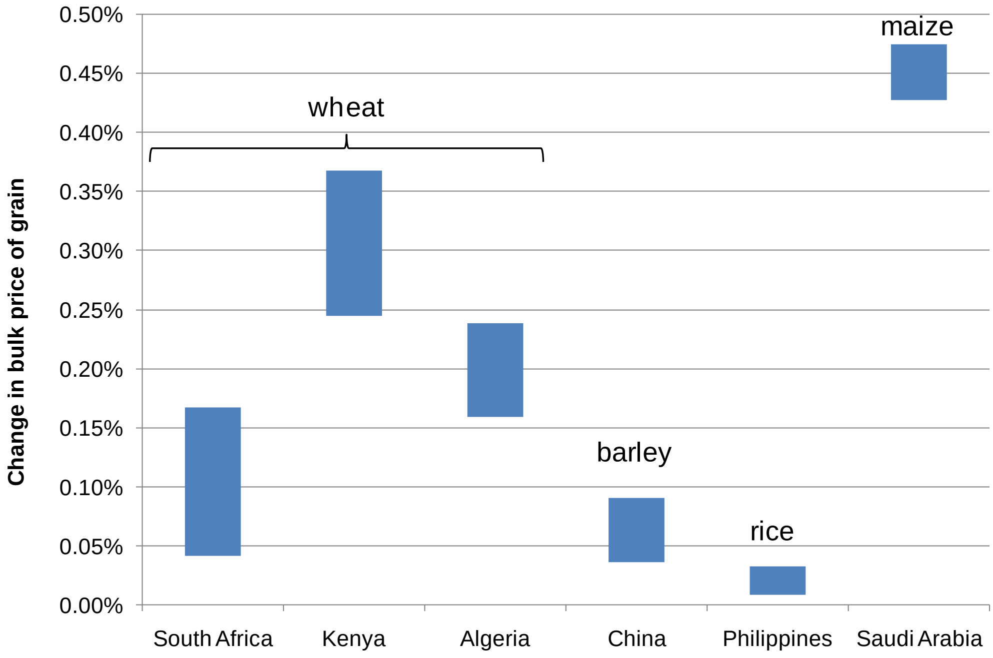
Source: Vivid Economics calculations based on FAO and OECD Maritime Transport Cost data.

Asterisks indicate inferred data based on routes covering a comparable distance.

4.2.8 Discussion

According to these examples, a high share of sea-borne imports is assumed to lead to a high cost pass-through rate, higher impacts on consumers, gains for domestic producers and lower costs for sea-borne producers. However, this is not a hard and fast rule. As the Algerian example shows, short sea routes may limit price increases, even with high import dependence. As discussed in the Chinese and Philippine examples, factors such as market segmentation (exporters' products being distinguished by quality or purpose) and constraints on the ability to increase domestic production might cause cost pass-through rates to be higher than the import share would suggest. Figure 16 summarises the changes in grain prices estimated for the markets examined.

Figure 16 Only countries with import shares above 60 per cent (but not all of these) experience price increases above 0.3 per cent



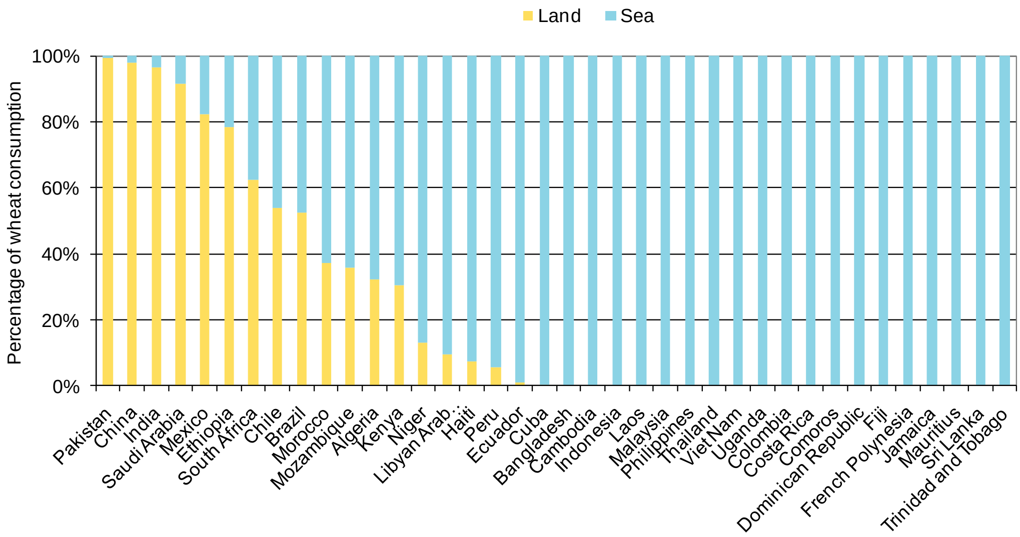
Source: FAO and Vivid Economics calculations

It is possible to gain an impression of which other countries might be affected by bunker price increases from the market share of sea-borne imports which each exhibits. Figure 17 shows this for wheat in a selection of developing countries.

Relatively few developing countries source a large share of their wheat consumption domestically. Many arid and low latitude countries are not suited to wheat production, while others, such as Mexico, import substantial amounts overland. Following an increase in bunker fuel price, the greatest wheat price increases might occur in South-East Asia and equatorial South America, with negligible increases in India and China.

Similar charts showing the share of sea-borne imports in the barley, rice and maize are presented in Annex 2.

Figure 17 Wheat prices are likely to increase the most in East and South-East Asia where all wheat is imported via seaborne routes



Source: FAO and Vivid Economics calculations

The routes examined are unlikely to be representative of the broader grain market, because the bulk of the trade in grain is among the wealthier regions of North America, Japan, Australia and the EU. In particular, the share of the total cost burden borne by the developing world will almost certainly be much higher in the six markets analysed here than for all global grain markets on average.

5 Containers

Key messages

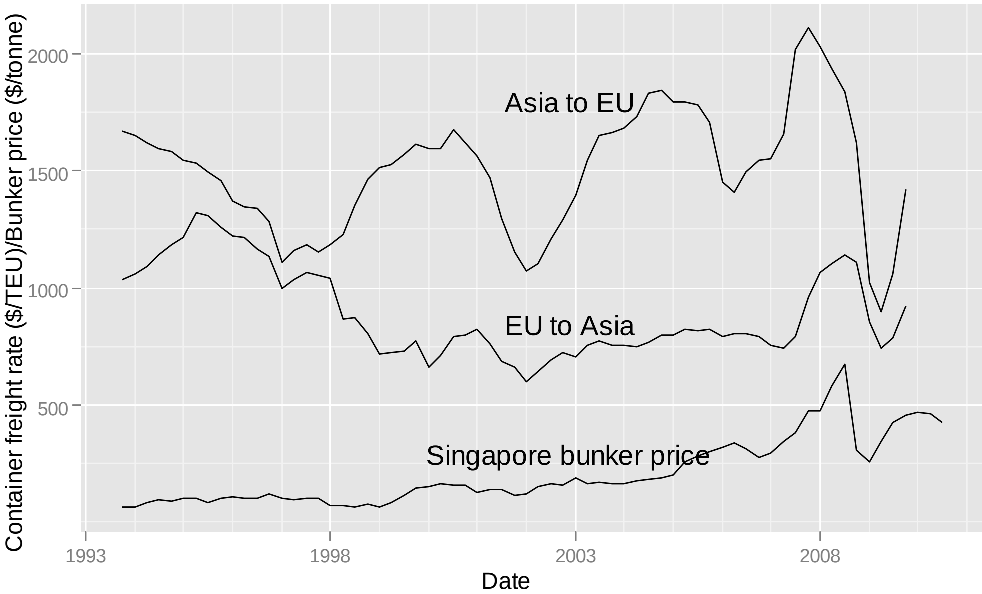
- Container freight rates are considerably less correlated with bunker prices than for the other ship types examined. It is likely that other factors are more important determinants of freight rates in the container market than in other shipping markets. Overall, the freight rate elasticity with respect to bunker price is low, at between 0.1 and 0.2.
- Apparel and furniture are goods with substantial value traded by sea into Europe.
- China is the predominant overseas supplier for both products. Sea-borne imports make up around 42 and 69 per cent of the EU apparel and furniture markets, respectively. Moderate and moderate-to-high cost pass-through rates could consequently be expected from an increase in the bunker price.
- Higher *ad valorem* freight rates and the greater share of sea-borne imports might induce greater consumer impacts for furniture than apparel. However, in both cases, price increases are 0.2 per cent or less.
- Overall, producers might gain slightly in the case of furniture, but not apparel, due to the small size of the price increase in the latter case.
- The heterogeneity of these product categories and lower quality of data mean that the results should be treated with more caution than the bulk commodities results.

5.1 The effect of bunker price increases on container freight rates

5.1.1 There is considerable variation in container price patterns

Figure 18 shows historical container freight rates since 1993 for the Asia-EU and EU-Asia routes, along with the corresponding Singapore bunker price. The Asia-to-EU freight rate shows greater variance than the reverse route. The correlation between bunker prices and freight rates on this route is weak (for scatter plots illustrating this, see Annex 2). EU-to-Asia container freight rates appear more correlated with bunker prices, with the exception of the beginning of the sample period. There is much less correlation between freight rates across different routes than for the other products examined.

Figure 18 Container freight rates do not always move in tandem



Source: Vivid Economics and UNCTAD data

5.1.2 *Bunker price is a less important determinant of freight rates for containers than for the bulk commodities*

The generally weak correlation between bunker price and container freight rates suggests that other variables might be important determinants of freight rates. For this reason, the OLS regression model used to derive the container freight rate elasticities contains a number of other variables, namely:

- the size of the global container fleet in TEU equivalents;
- the volume of trade on route in question; and
- the volume of trade on routes departing from Europe; or
- the measure of imbalance on container routes used by UNCTAD (calculated as $(q_1-q_2)/(q_1+q_2)$, where q_1 is the volume of trade on the route and q_2 is the volume of trade on the reverse route).

Note that only one of the latter two variables is used, as they are alternative means of capturing the same dynamic. The former set of controls are more general and so these estimates are to be preferred; the imbalance measure is included to allow a more direct comparison with the UNCTAD analysis. Note that UNCTAD did not include measures of the supply of container ships in its modelling, and this might be the source of the difference in the estimates.

Table 16 presents the freight rate elasticity results for the Asia-US, Asia-EU and EU-US routes, along with their backhaul complements.

Table 16 On average, a ten per cent increase in bunker price increases container freight rates by between one and two per cent

Origin	Destination	Elasticity estimate (OLS) Destination / origin control	Elasticity estimate (OLS) Imbalance control
Asia	US	0.207 (0.070)	0.252 (0.071)
US	Asia	0.041 (0.066)	0.038 (0.069)
EU	Asia	0.260 (0.087)	0.338 (0.084)
Asia	EU	0.057 (0.074)	0.135 (0.079)
US	EU	0.117 (0.093)	0.191 (0.092)
EU	US	0.119 (0.051)	0.236 (0.049)
Average		**0.124**	0.198
UNCTAD global average			0.291

Source: Vivid Economics using UNCTAD, Containerisation International and Clarkson's data. Note: Figures in brackets are standard errors.

It is difficult to discern a pattern in these results. On average, a 10 per cent increase in bunker price could be expected to increase container freight rates by about 1.2 per cent.

5.2 Description of selected container goods markets

5.2.1 Furniture and apparel are among the major container goods imported from China to the EU

Table 17 shows the top ten container products by value imported by the EU from China. For each product, exports to the EU make up 15-48 per cent of total Chinese exports, while these products collectively make up two-thirds of the value of Chinese exports. The EU is therefore a major market for Chinese-manufactured container products.

Table 17 The EU is a major market for most of the top ten container products on the China-EU route

	EU imports from China	Total Chinese exports	Total EU imports
	All figures in $US bn 2008		
Nuclear reactors, boilers, machinery, etc	73	269	719
Electrical, electronic equipment	93	342	570
Vehicles other than railway, tramway	6	39	559
Plastics and articles thereof	8	30	205
Optical, photo, technical, medical, etc apparatus	7	43	145
Articles of iron or steel	12	48	117
Articles of apparel, accessories, not knit or crochet	25	52	84
Furniture, lighting, signs, prefabricated buildings	16	43	81
Articles of apparel, accessories, knit or crochet	19	61	76
Wood and articles of wood, wood charcoal	3	9	54

Source: UNCTAD/WTO and OECD Maritime Transport Cost database

In addition, imports from China represent at least a 20 per cent share of total EU imports for articles of apparel and furniture. These products were selected for analysis[10]. Both of these product categories are diverse and contain a range of high-

[10] While the Chinese share of the EU market for both knitted and non-knitted apparel is over 20 per

value and low-value products, and many products within a category will not be substitutes for each other. The comparative competitiveness and market share of domestic and land-based exporters may vary according to these attributes. Manufacturers may also react to lower margins by changing the type or quality of product as well as quantity. This complicates any assessment of the economic impact of freight rate increases compared to bulk commodities.

Further caveats are necessary. The heterogeneity within product categories creates inconsistencies between datasets which use different industrial classifications. It also means that calculations have to deal in prices per tonne which do not reflect prices used for trading goods. Thus the calculations in this section are based on less robust data than in the other sections and should be treated with more caution.

5.2.2 Cost pass-through may be low for apparel

Figure 19 shows the provenance of articles of non-knitted wearing apparel sold in the EU. Over half (by value) is manufactured in the EU, with a further 6 per cent produced by land-based exporters. China is the largest overseas supplier, with the remainder of imports mostly manufactured in North Africa, South Asia and South-East Asia.

The majority share of land-based production might limit cost pass-through to around 50 per cent, although this could vary significantly across segments of the market. For example, overseas suppliers are likely to be concentrated in the low-value end of the market and the capacity of European producers to be competitive in this band might be lower than their market share by value suggests. Thus, there could be a higher cost pass-through rate for low value products. Conversely, there could be a lower cost pass-through for high value products.

Table 18 presents some summary statistics of the apparel market and an assessment of the potential impacts of a higher bunker price, using a freight rate elasticity of 0.12, and therefore resulting in a freight rate increase of 1.2 per cent. The low cost pass-through rate and relatively low *ad valorem* transport costs, give an estimated price increase of less than 0.05 per cent. Net costs to producers and consumers are estimated at less than $30 and $37 million respectively.

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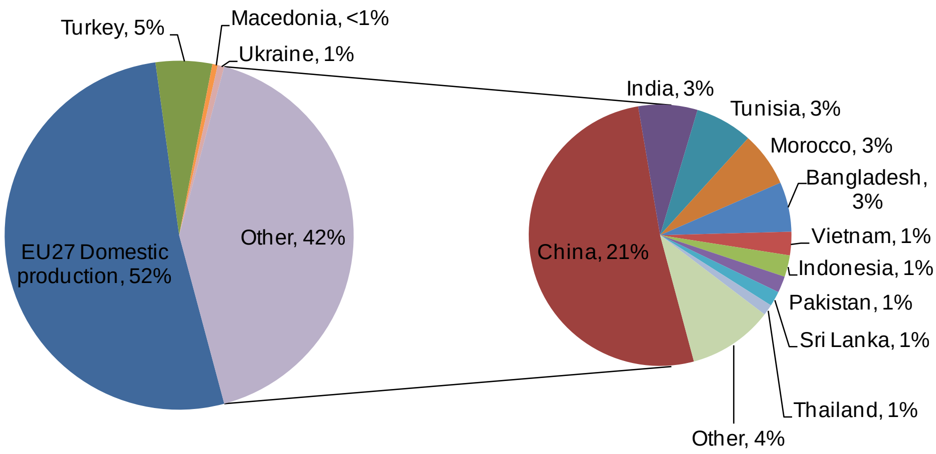
cent, for ease of data collection, only non-knitted apparel is taken forward for this analysis.

Figure 19 Less than half of the EU apparel market is supplied by sea-borne imports



Source: UNCTAD/WTO and Eurostat

Table 18 EU apparel price increases are very small due to a low *ad valorem* freight rate and low cost pass-through

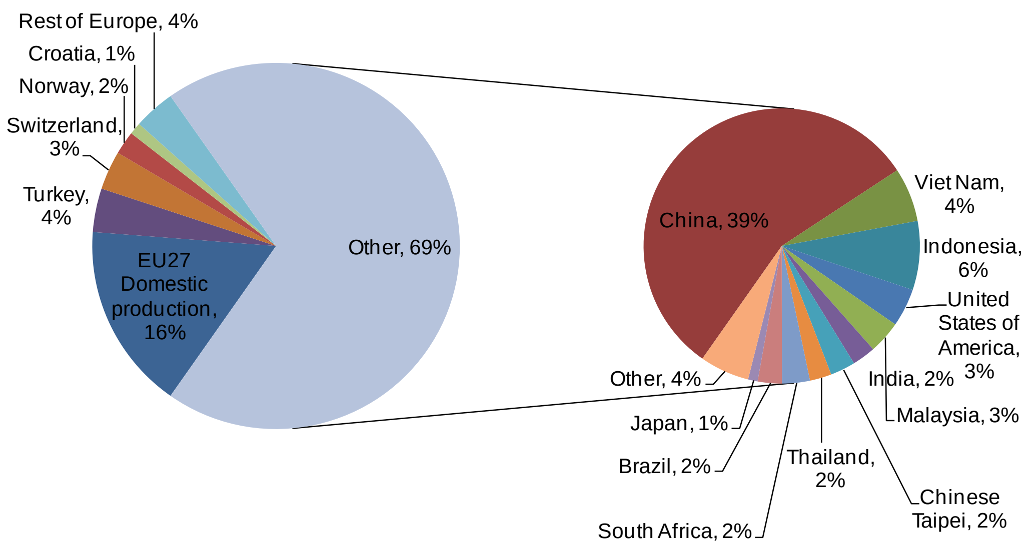
Element	Value
Initial price ($/tonne)	9,400
Initial total demand (mega-tonnes)	9.5
Market size ($m per annum)	89,000
Market share of sea-borne importers	42%
Freight rate: per tonne and *ad valorem*	from China: $809 (8.6%)
Elasticity of freight rates w.r.t. bunker price	0.12
Cost pass-through rate	10–40%
Increase in freight rates: per tonne and *ad valorem*	$9.71 (0.1%)
Resulting increase in price: per tonne and as %	$0.97–$3.88 (0.01–0.04%)
Reduction in demand (kilo-tonnes and %)	1–4 (0.01–0.04%)
Cost to overseas producers from change in margin ($m)	23.2 – 34.9
Gain to land producers from change in margin ($m)	5.4 – 21.4
Cost to consumers from increase in price ($m)	9.23 – 36.9
Loss of consumer welfare from reduction in consumption	negligible

Source: Vivid Economics calculations based on UNCTAD/WTO and Eurostat data.

5.2.3 *Cost pass-through is likely to be higher for furniture*

Figure 20 shows the share of imports and domestic production for furniture sold in the EU. This time, only around 17 per cent is manufactured in the EU, with a further 14 per cent derived from land-based exporters. Over two-thirds of furniture comes to the EU by sea. China is again the largest foreign supplier overall, with a significant proportion of imports also from South-East Asia.

Figure 20 China has a greater market share of the EU furniture market than land-based producers



Source: UNCTAD/WTO and Eurostat

The greater market share of sea-based exporters suggests a higher cost pass-through, and we assume that 60–90 per cent could be expected in this market. Again, segmentation of the market may result in differences in cost pass-through rates for higher and lower value goods.

Table 19 presents an assessment of the impacts on the EU furniture market of a 10 per cent increase in the bunker price. The higher cost pass-through rate and higher *ad valorem* transport cost leads to a larger price increase than for apparel of 0.15-0.23 per cent. Net costs to producers are estimated at $5 million or less, with potential net gains to producers. EU consumers bear almost all the cost, with consumer cost placed at $30-45 million.

Table 19 Higher *ad valorem* freight rates and a greater dependence on sea-borne imports leads to a proportionally much greater consumer impact for furniture than apparel

Element	Value
Initial price ($/tonne)	2,700
Initial total demand (mega-tonnes)	7.2
Market size ($m per annum)	19,500
Market share of sea-borne importers	69%
Freight rate: per tonne and *ad valorem*	from China: $430 (16%)
Elasticity of freight rates w.r.t. bunker price	16%
Cost pass-through rate	60–90%
Increase in freight rates: per tonne and *ad valorem*	$6.88 (0.26%)
Resulting increase in price: per tonne and as %	$4.13–$6.19 (0.15–0.23%)
Reduction in demand due to price increase (kilo-tonnes and %)	11.6–16.6 (0.16–0.23%)
Cost to overseas producers from change in margin ($m)	3.4 – 13.8
Gain to land producers from change in margin ($m)	9.3 — 13.9
Cost to consumers from increase in price ($m)	29.9 – 44.9
Loss of consumer welfare from reduction in consumption	negligible

Source: Vivid Economics calculations based on UNCTAD/WTO and Eurostat data.

6 Conclusions

The impacts of an increase in the bunker price vary across product markets, both in terms of magnitude and distribution of impacts. Two general observations can be made:

— where cost pass-through is higher, more of the cost is borne by local consumers, the impact on exporters is less negative, and the gains to local producers from increased profit margins are larger; and
— product price rises are less than 1 per cent, except for iron ore, and of the three examples where changes in market share could be estimated, only iron ore might result in a significant shift in market share away from overseas exporters to land-based producers.

This second point is made in the context of much larger changes in both bunker price and freight rates over the past two decades. Variation in freight rates due to the dynamics of global oil, shipping and product markets may dwarf any potential effects of an MBM.

The confluence of three factors led the China iron ore example to stand out. First, iron ore freight rates are estimated to have the greatest sensitivity to bunker price of any of the products examined. A 10 per cent increase in the bunker price results in around 10 per cent increase in freight rates. Second, iron ore has one of the highest *ad valorem* freight rates of the products examined, at 23–53 per cent; although some of the grain freight rates fall within this range, most are at the lower end or below. Finally, the market share of sea-borne imports in total consumption in China is about 50 per cent.

The example illustrates the finding that sea-borne exporters may be most vulnerable to adverse impacts for products and routes where:

— the freight rate elasticity is high;
— *ad valorem* freight rates are high; and
— cost pass-through is low or moderate; that is, where overseas producers have a low or moderate market share.

It is the second and third of these circumstances which generate a higher expected impact on the furniture market in Europe than the apparel market.

In contrast, for some of the grain market analyses, such as wheat in Algeria or Maize in Saudi Arabia, it is consumers who might bear most of the cost, although in all cases it might be a small percentage of the cost of consumption, because of a low share of sea-borne imports. Where the freight rate elasticity and *ad valorem* freight rates are high, these impacts may be more significant, such as in grain markets with long sea import routes.

The principal reason why the crude oil market analysis shows little impact from a 10 per cent increase in the bunker price is the low *ad valorem* freight rate for this product, 2–6 per cent. Impacts are low even when a country is wholly dependent on sea-borne imports, such as South Korea, whose cost pass-through rate is close to 100 per cent.

Given that the freight rate elasticity is such an important factor in determining the magnitude of impacts, it is worth considering why it varies so much between the products and routes examined. The elasticity of freight rates with respect to bunker price is estimated at 0.37 for VLCCs, 0.25 for Panamax grain vessels, 0.96 for Capesize ore vessels and 0.11 for container ships. There are several factors which may account for these differences.

The elasticity is related to the rate of cost pass-through from *ship-owners to exporters* through the freight rate. For example, if bunkers are 50 per cent of the total costs of a ship and the elasticity of the freight rate with respect to bunker price is 0.20, then the overall cost pass-through would be 0.20/0.50 = 40 per cent. Vessels for which bunkers is a higher share of total costs would generally be expected to have a higher elasticity. The cost pass-though rate is also related to market structure. Markets which are more competitive and have larger numbers of large firms competing tend to have higher rates of cost pass-through.

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Annex 1: Scope of work

(i) The global grain market. Statistical methods were used to examine the pass-through of bunker costs into freight prices on some major grain routes. Quantitative data were used to explore the impact on consumer prices, producer profits and trade flows, but a detailed economic model was not used to do this.

Results for a selection of sub-regions (below continent level) were reported and impacts on developed and less developed areas were distinguished.

(ii) Iron ore into China. Statistical methods were used to examine the pass-through of bunker costs into freight prices on this route. A detailed economic model was used to explore the impact on consumer prices, producer profits and trade flows.

(iii) Crude oil into the US Gulf Coast and into South Korea. Statistical methods were used to examine the pass-through of bunker costs into freight prices in these two consumer markets. A detailed economic model was used to explore the impact on consumer prices, producer profits and trade flows in these two consumer markets.

(iv) Containers in the Caribbean. Data were not available to examine these routes.

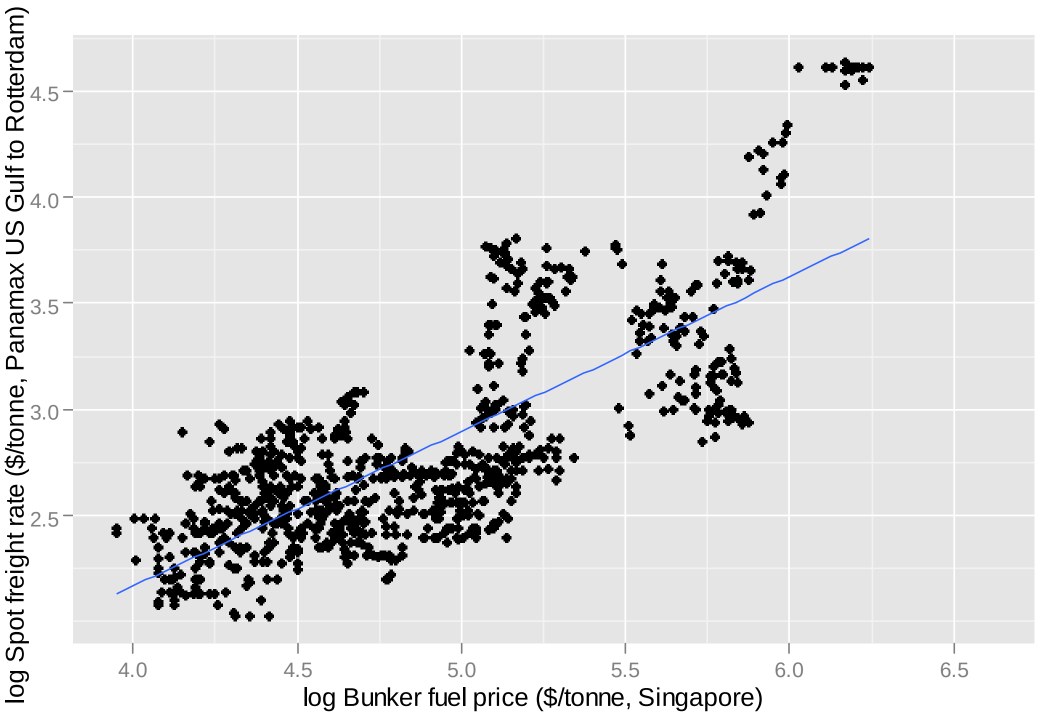
(v) Containers into Europe. Statistical methods were used to examine the pass-through of bunker price into container rates on six major container routes. For several example products on the East Asia to Europe route, quantitative data were used to explore the impact on consumer prices, producer profits and trade flows, but the detailed economic model was not used.

Annex 2: Further results

This Annex contains a few further charts not presented in the main body of the report, displaying data which the reader may find of interest, namely:

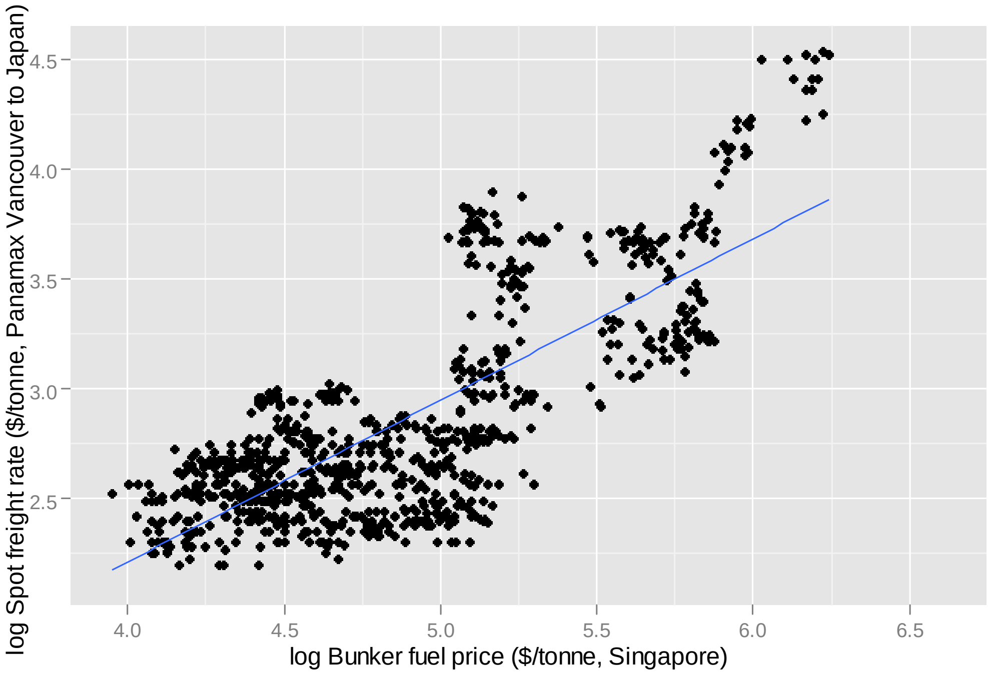
— scatterplots illustrating correlations between freight rates for grain, iron ore and containers, and bunker price (or more precisely, their natural logarithms); and
— bar charts showing the share of sea-based and land-based production in the consumption of barley, rice and maize of a selection of developing countries (see Section 4.3.8).

Figure 21 Freight rate vs. bunker price for the US Gulf to Rotterdam grain route



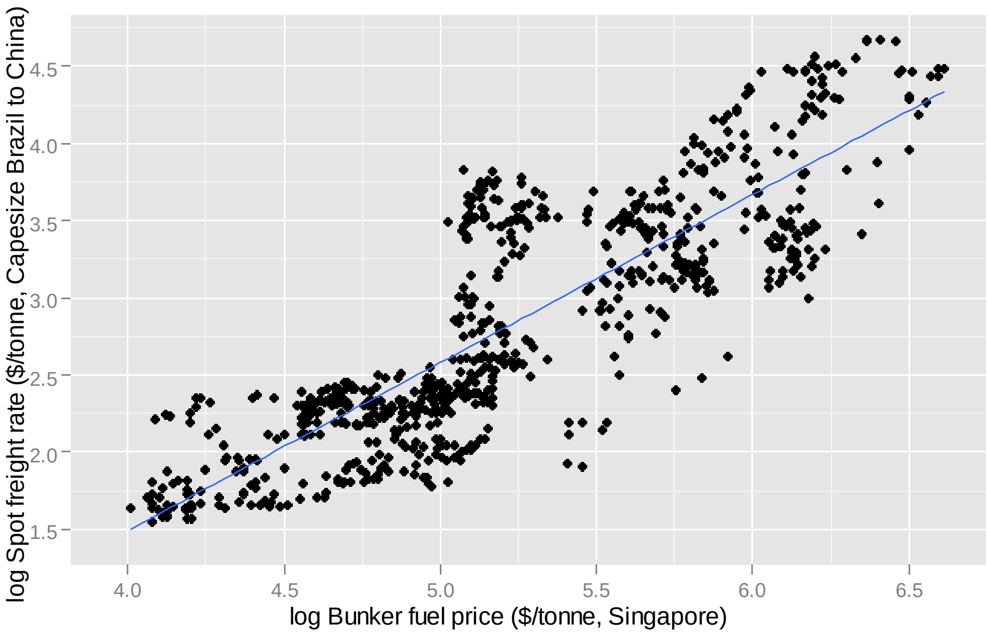
Source: Vivid Economics and Clarksons data

Figure 22 Freight rate vs. bunker price for the Vancouver to Japan grain route



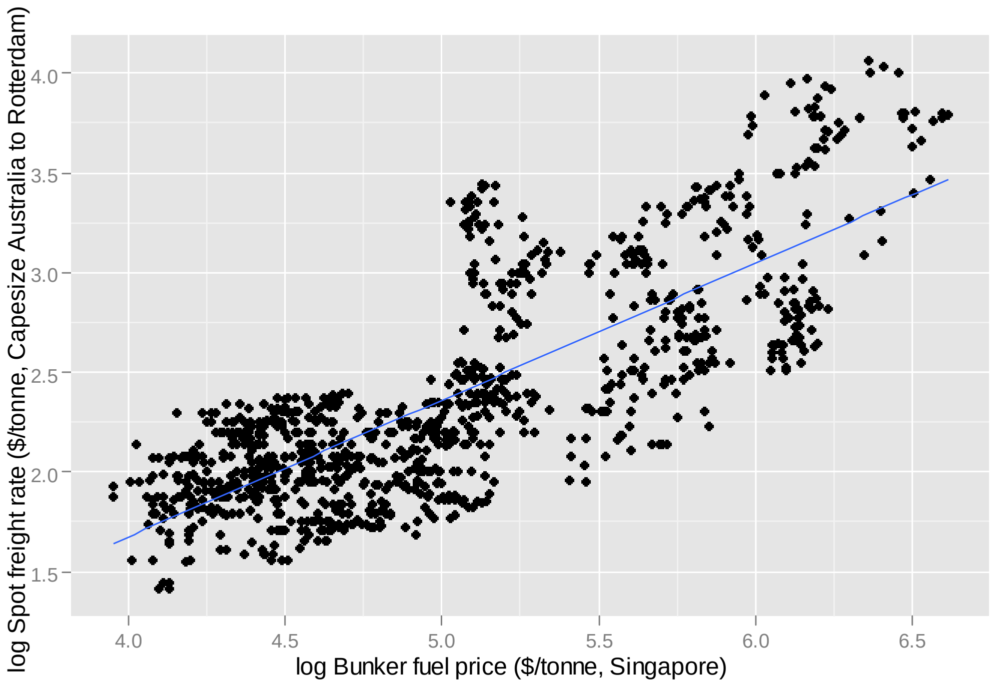
Source: Vivid Economics and Clarksons data

Figure 23 Freight rate vs. bunker price for the Brazil to China iron ore route



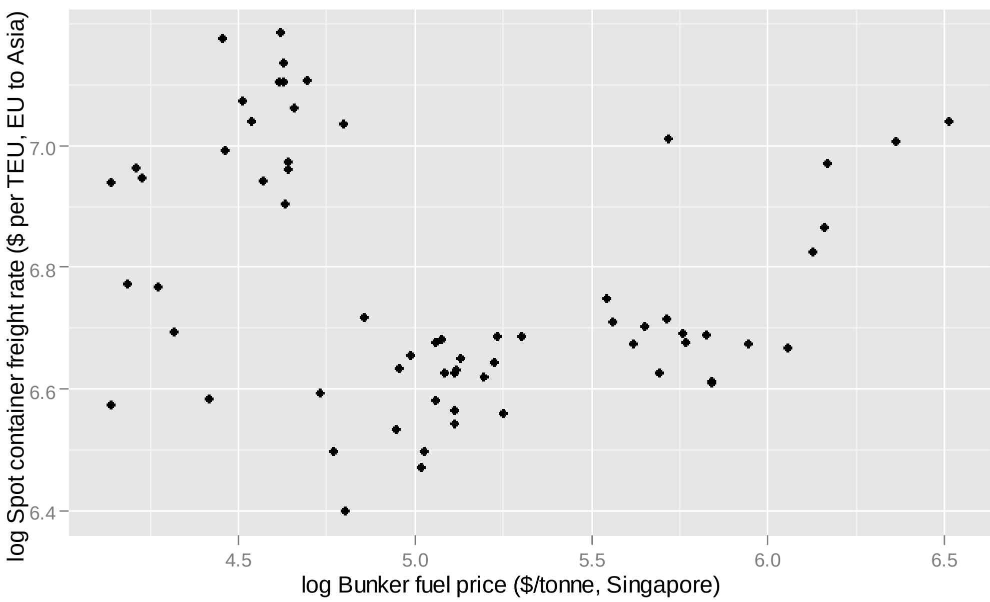
Source: Vivid Economics and Clarksons data

Figure 24 Freight rate vs. bunker price for the Australia to Rotterdam iron ore route



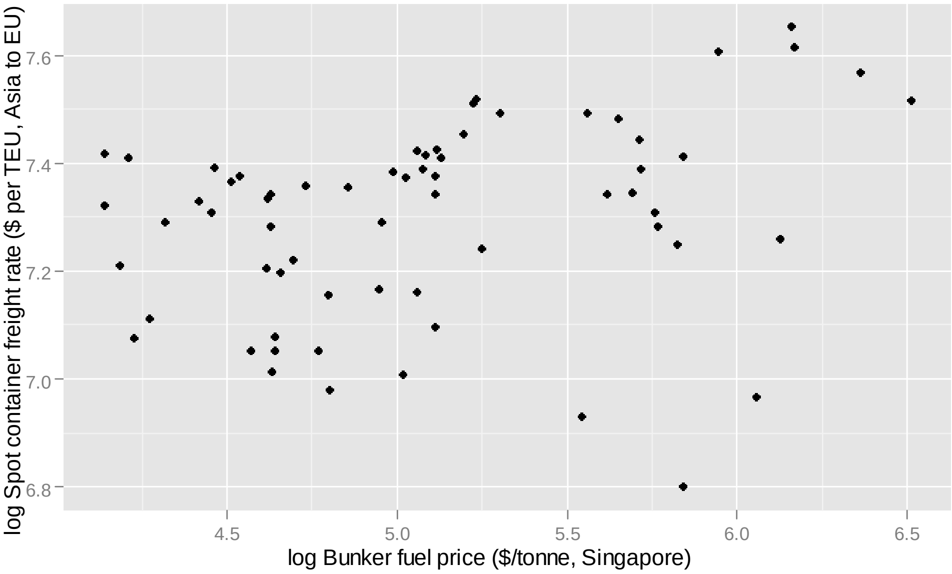
Source: Vivid Economics and Clarksons data

Figure 25 Freight rate vs. bunker price for the EU to Asia container route



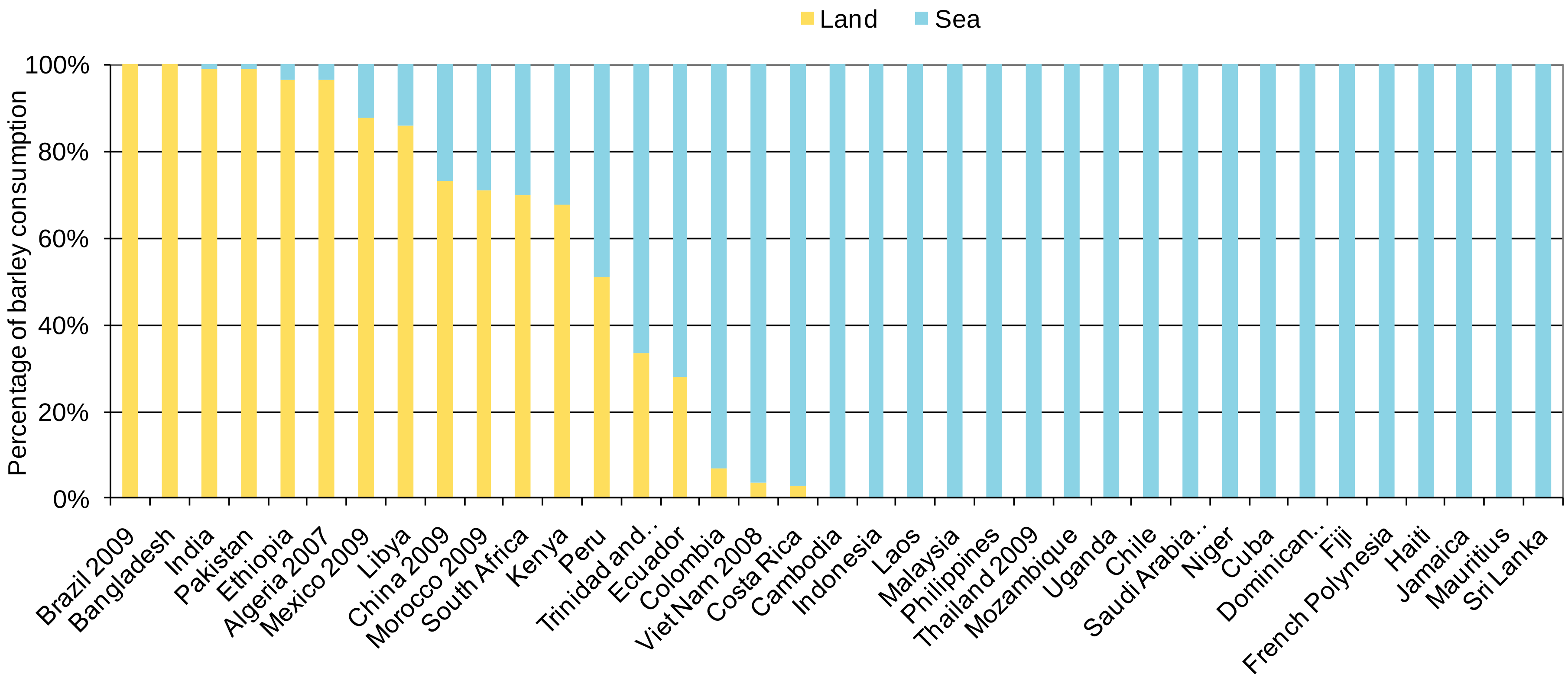
Source: Vivid Economics and Clarksons data

Figure 26 Freight rate vs. bunker price for the EU to Asia container route



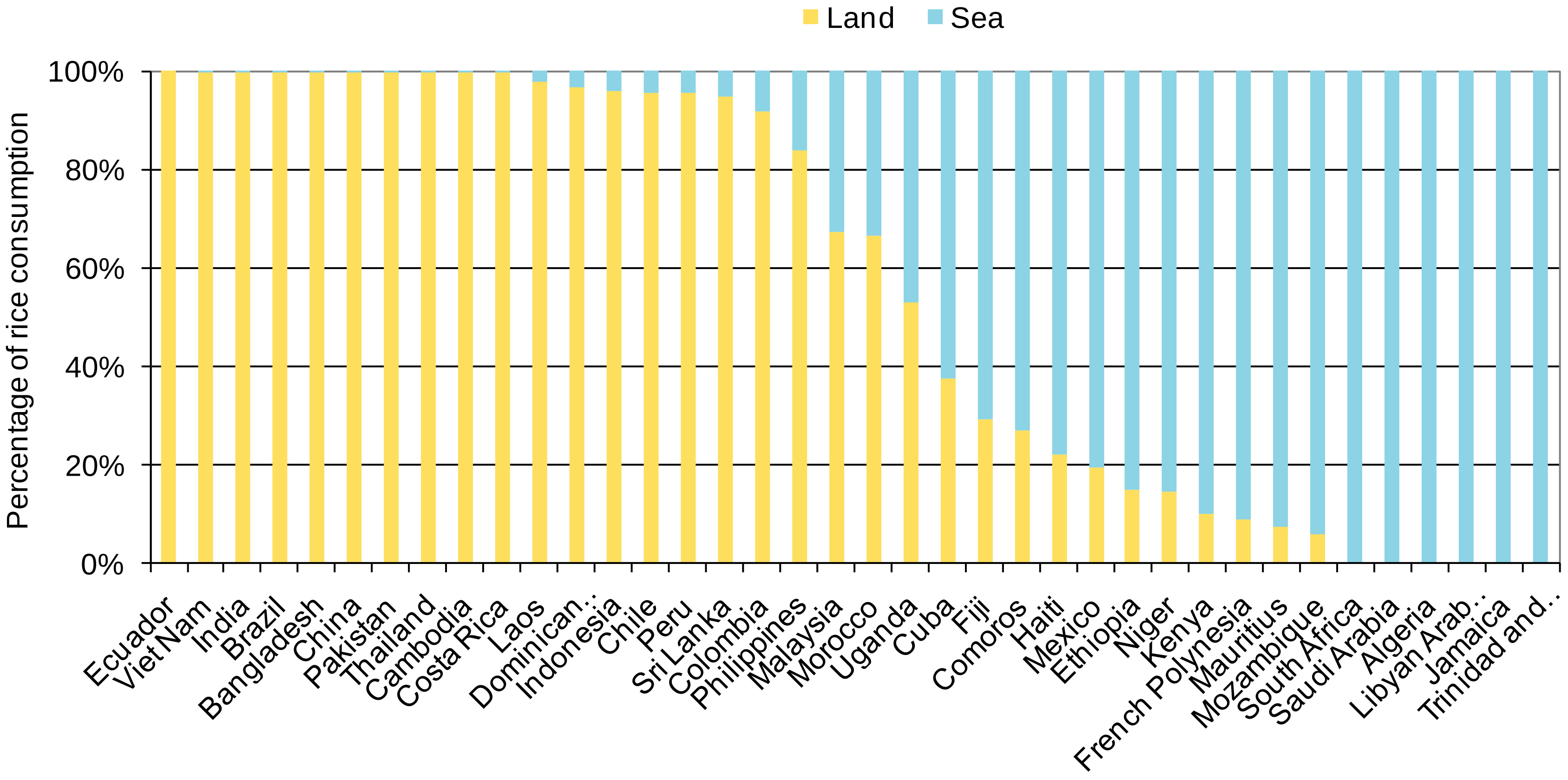
Source: Vivid Economics and Clarksons data

Figure 27 Share of land-based and sea-based production of barley in consumption in a selection of developing countries



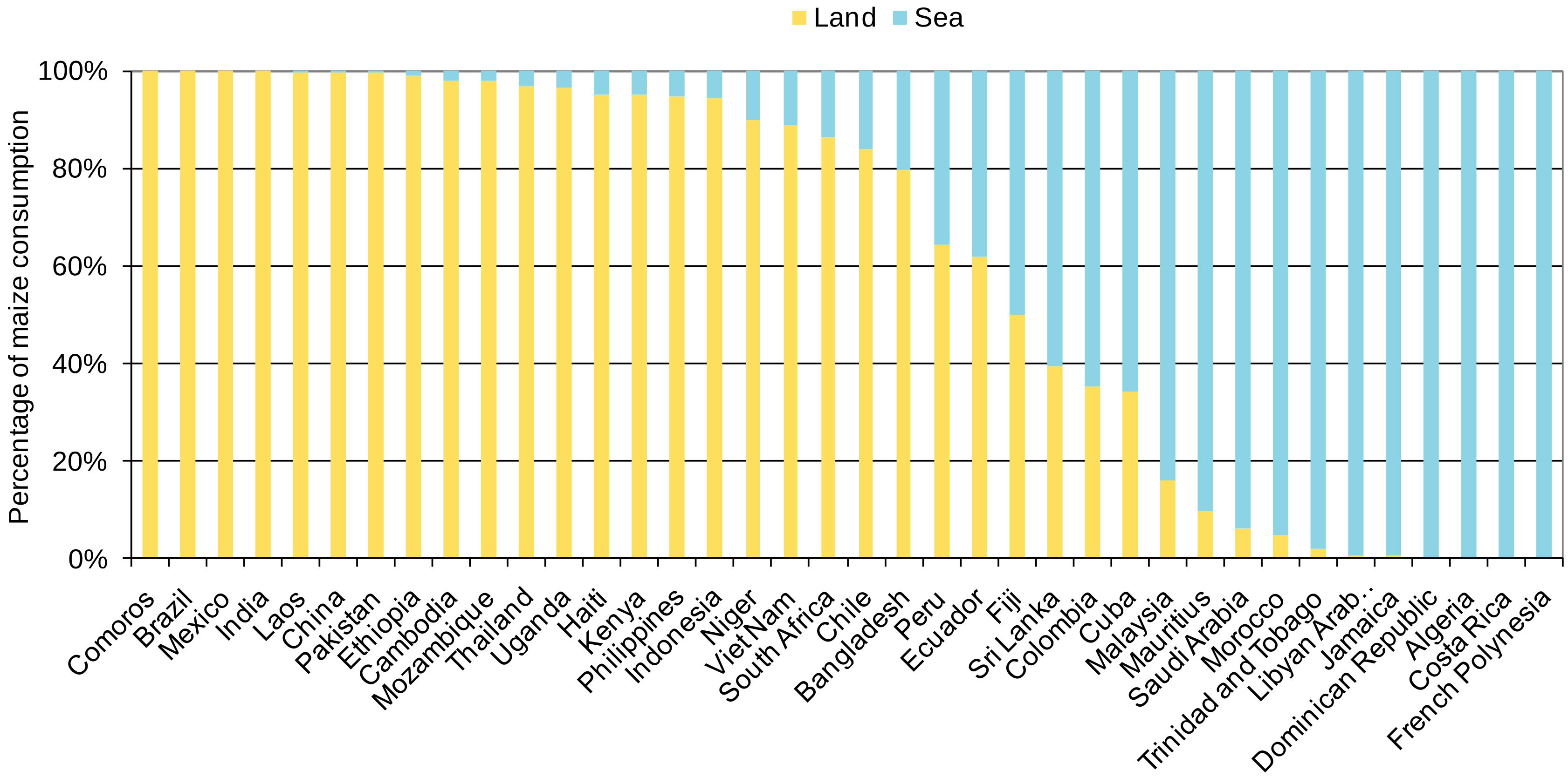
Source: FAO

Figure 28 Share of land-based and sea-based production of barley in consumption in a selection of developing countries



Source: FAO

Figure 29 Share of land-based and sea-based production of barley in consumption in a selection of developing countries



Annex 3: Details of econometrics

A3.1 Data used

Data were assembled for 9 different VLCC crude oil routes, 11 different Capesize ore routes, 5 different grain routes, 6 different container routes and 12 different sources of bunker fuels. The source of the data is Clarksons and, for container freight rates, UNCTAD.

The data are generally available weekly, with the exception of the container data which is available quarterly, over a number of years. For some routes, data are available reaching as far back as 1987 while, for other routes, data has only been collected over the last few years. Data for all freight rates and bunker prices, with the exception of VLCCs, are measured in dollars per tonne over the particular route.

The units of the VLCC freight rates are in 'Worldscale Units', and are set relative to a benchmark price in each year. This means that freight rates are not strictly comparable across years as the benchmark is reviewed annually. This can be taken into account by including year dummy variables in the statistical analysis so that the results are unaffected by the changing units.

It was not possible to source any data on a container freight route into a small island developing state, and discussion with industry contacts suggests that the Containerisation International data used here is the only suitable data set.

A3.2 Model specifications

A3.2.1 Ordinary Least Squares

The most basic approach to estimating the elasticity of the freight rate with respect to bunker price is to use a method known as *ordinary least squares* (OLS). This technique is relatively simple, but can only be used when the data satisfy certain conditions. The equation used in the estimation is as follows:

$$lnS_t = \alpha + \beta_1 lnB_t + u$$

where *ln* is the natural logarithm, S_t is the spot freight rate and B_t the spot bunker price at time period *t* (weekly or quarterly), α a constant, and u a random error term. The coefficient β_1 is an estimate of the elasticity.

For VLCCs, some authors have suggested that the elasticity will be higher for higher bunker prices. In this case a slightly different equation is used:

$$S_t = \alpha + \beta_1 B_t + u$$

The elasticity, which varies over time, is then given by $\beta_1(B_t/S_t)$.

The basic equation is extended for the estimation of container freight rate elasticities, to account for the apparent importance of other factors in determining freight rates:

$$S_t = \alpha + \beta_1 B_t + \beta_2 TEU_t + \beta_3 V1_t + \beta_4 V2_t + \beta_5 V3_t\ u;$$

Where TEU is the size of the global container fleet in TEU equivalents, V1 is the volume of trade on the route in question, and V2 and V3 are the volumes of trade on two routes departing from the region (in this case, departing from the EU). For the iron ore, grain and crude oil routes, measures of the global volume of trade in the product and the total capacity of the relevant shipping fleet (in DWT equivalents) are included in a similar manner.

Note that either the volume of trade on the two plausible follow-on routes for liner services or the imbalance measure is included in the regressions as they are alternative means of capturing the same dynamic, although the former set of controls are more general and so these estimates are to be preferred.

A3.2.2 Error Correction Model

Some series in this analysis are better analysed using an *error correction model* (ECM) to account for the dynamic nature of the relationship between the variables. The equation for this type of model is:

$$\Delta lnS_t = \alpha + \beta_2 lnS_{t-1} + \beta_3 lnB_{t-1} + \beta_4 \Delta lnB_t + u$$

where Δ is the difference operator (i.e. $\Delta x_t = x_t - x_{t-1}$) and *t*-1 denotes the time period before *t*.

There is assumed to be a long-run relationship between shipping spot rates and bunker prices and short-term variation in both variables away from this long-run equilibrium relationship. The inclusion of both lagged bunker prices and lagged spot prices accounts for an adjustment towards equilibrium from last period's shock, and the inclusion of changes in bunker prices allows for an adjustment towards a new equilibrium resulting from the change in the bunker price. The long-run elasticity of spot freight rates with respect to bunker price, which can be obtained by inserting $x_t = x^*$ for all t, can be calculated as $-\beta_3/\beta_2$.

Note it is not possible to use this methodology for VLCC routes because the units are different each year, nor for the container routes because there are insufficient data (quarterly, rather than weekly). The ECM estimates should generally be preferred to the OLS estimates in other cases.

A3.3 Interpretation of results

A3.3.1 Standard errors

Note that in the results, standard errors are presented along with the estimates to enable the interested reader to conduct additional statistical tests. To construct a 95 per cent confidence interval, multiply the standard error by 1.96 and add and subtract this to the estimate to give the upper and lower bounds, respectively.

A3.3.2 R^2 values for the regressions calculating the elasticity of freight rates with respect to bunker price

Table 20 R^2 values for the container shipping regressions

Route	OLS destination/origin control	OLS imbalance control
Asia to US	0.368	0.358
US to Asia	0.799	0.774
EU to Asia	0.502	0.434
Asia to EU	0.589	0.469
US to EU	0.618	0.571
EU to US	0.807	0.736

Source: Vivid Economics calculations

Table 21 R^2 values for the VLCC shipping regressions

Route	Constant elasticity OLS model	Variable elasticity OLS model
Ras Tanura-Rotterdam	0.686	0.613
Ras Tanura-Ulsan	0.640	0.558
Ras Tanura-Chiba	0.627	0.551
Ras Tanura-Loop	0.666	0.577
Bonny Offshore-Loop	0.672	0.615
Bonny offshore-Kaohsiung	0.669	0.599
Ras Tanura-Ain Sukhna	0.648	0.567
Sidi Kerir-Rotterdam	0.712	0.659
Ras Tanura-Singapore	0.599	0.526

Source: Vivid Economics calculations

Table 22 R^2 values for the grain shipping regressions

Route	OLS model	ECM model
US Gulf-Rotterdam	0.873	0.020
US Gulf-Rotterdam (HSS)	0.856	0.021
US Gulf-Japan (HSS)	0.894	0.018
Vancouver-Japan	0.886	0.015
US Gulf-Japan (HSS, supramax)	0.876	0.183

Source: Vivid Economics calculations

Table 23 R^2 values for the Capesize iron ore regressions

Route	OLS model	ECM model
Narvik-Rotterdam	0.703	0.024
Tubarao-Rotterdam	0.748	0.035
Tubarao-Japan	0.745	0.032
Tubarao-Beilun	0.770	0.069
Nouadhibou-Rotterdam	0.772	0.030
W. Australia-Rotterdam	0.696	0.025
W. Australia-Japan	0.672	0.021
Saldanha Bay-Beilun	0.579	0.061
W. Australia-Beilun	0.558	0.056
Goa-Beilun	0.587	0.073
Port Cartier-Rotterdam	0.558	0.077

Source: Vivid Economics calculations

Annex 4: Sensitivity analysis

This section presents the modelling results for the Chinese iron ore market, the US crude market and the South Korean crude market when the increase in bunker price is set at each of five and fifteen per cent.

6.1 Results tables for a five per cent increase in bunker prices

Table 24 The Chinese iron ore market with a five per cent increase in bunker prices

	Initial	Final	Change	Initial	Final	Change
	Spot market including Chinese state-owned firms			Spot market excluding Chinese state owned firms		
Size (million tones p.a.)	412.3	409.6	-0.66%	289.1	287.0	-0.72%
Price ($ per tonne)	111.9	112.8	0.82%	111.9	112.9	0.90%
Domestic market share	46.0%	53.9%	7.87%	23.0%	33.0%	10.02%
Land-based market share	46.3%	54.3%	8.03%	23.4%	33.7%	10.27%
Sea-based import market share	53.7%	45.7%	-8.03%	76.6%	66.3%	-10.27%
Average added cost for sea importers ($ per tonne)		1.57			1.55	
Cost pass-through for sea importers		58.8%			65.1%	

Source: Vivid Economics calculations

Table 25 Changes in market share and margin for foreign suppliers in the Chinese iron ore market with a five per cent increase in bunker prices

	Original market share	Change in market share in percentage points	Change in margin ($/tonne of metal)	Original market share	Change in market share in percentage points	Change in margin ($/tonne of metal)
	Spot market including Chinese state-owned firms			Spot market excluding Chinese state owned firms		
Australia	29.4%	-0.3%	-0.3	42.0%	-0.2%	-0.2
Brazil	8.3%	-1.5%	-1.9	11.9%	-2.0%	-1.8
China	46.0%	+7.9%	0.9	23.0%	+10.0%	1.0
India	11.2%	-2.9%	-0.6	16.0%	-3.3%	-0.5
Iran	0.4%	-0.2%	-1.3	0.6%	-0.3%	-1.2
Rest of the World	2.7%	-2.7%	-1.9	3.9%	-3.9%	-1.8
South Africa	1.6%	-0.4%	-1.2	2.3%	-0.5%	-1.1

Source: Vivid Economics calculations

Table 26 The South Korean crude market with a five per cent increase in bunker prices

	Initial	Final	Change	Initial	Final	Change
	Oil price $95 per barrel			Oil price $60 per barrel		
Size (million tones p.a.)	116.7	116.7	-0.01%	116.7	116.7	-0.02%
Price ($ per tonne)	696.6	697.0	0.05%	440.0	440.4	0.09%
Domestic market share	0.0%	0.0%	0.00%	0.0%	0.0%	0.00%
Land-based market share	0.0%	0.0%	0.00%	0.0%	0.0%	0.00%
Sea-based import market share	100.0%	100.0%	0.00%	100.0%	100.0%	0.00%
Average added cost for sea importers ($ per tonne)		0.34			0.34	

Cost pass-through for sea importers		58.8%			65.1%	

Source: Vivid Economics calculations

Table 27 The US crude market with a five per cent increase in bunker prices

	Initial	Final	Change	Initial	Final	Change
	Oil price $95 per barrel			Oil price $60 per barrel		
Size (million tones p.a.)	742.8	742.8	0.00%	742.8	742.8	0.00%
Price ($ per tonne)	696.6	696.7	0.01%	440.0	440.07	0.02%
Domestic market share	36.9%	37.0%	0.01%	36.9%	37.0%	0.03%
Land-based market share	49.5%	49.5%	0.02%	49.5%	49.5%	0.04%
Sea-based import market share	50.5%	50.5%	-0.02%	50.5%	50.5%	-0.04%
Average added cost for sea importers ($ per tonne)		0.12			0.12	
Cost pass-through for sea importers		72.6%			73.3%	

Source: Vivid Economics calculations

Table 28 Market share and margin changes in the US crude market with a five per cent increase in bunker prices

Supplier	Original market share	Change in market share in percentage points	Change in sales in the US	change in margin ($/tonne)
US	36.9%	0.0	0.1%	0.1
Canada	12.5%	0.0	0.1%	0.1
Other Americas	20.9%	0.0	0.1%	0.0
Middle East	11.7%	0.0	-0.3%	-0.2
Africa	13.9%	0.0	-0.1%	0.0
Other	4.0%	0.0	-0.1%	0.0

Source: Vivid Economics calculations

6.2 Results tables for a fifteen per cent increase in bunker prices

Table 29 The Chinese iron ore market with a fifteen per cent increase in bunker prices

	Initial	Final	Change	Initial	Final	Change
	Spot market including Chinese state-owned firms			Spot market excluding Chinese state owned firms		
Size (million tones p.a.)	412.3	406.6	-1.38%	289.1	284.4	-1.60%
Price ($ per tonne)	111.9	113.8	1.73%	111.9	114.1	2.00%
Domestic market share	46.0%	62.7%	16.68%	23.0%	45.4%	22.42%
Land-based market share	46.3%	63.3%	17.02%	23.4%	46.4%	22.98%
Sea-based import market share	53.7%	36.7%	-17.02%	76.6%	53.6%	-22.98%
Average added cost for sea importers ($ per tonne)		4.55			4.50	
Cost pass-through for sea importers		42.6%			49.7%	

Source: Vivid Economics calculations

Table 30 Changes in market share and margin for foreign suppliers in the Chinese iron ore market with a fifteen per cent increase in bunker prices

	Original market share	Change in market share in percentage points	Change in margin ($/tonne of metal)	Original market share	Change in market share in percentage points	Change in margin ($/tonne of metal)
	Spot market including Chinese state-owned firms			Spot market excluding Chinese state owned firms		
Australia	29.4%	-1.9%	-1.8	42.0%	-2.1%	-1.5
Brazil	8.3%	-3.0%	-6.5	11.9%	-4.1%	-6.2
China	46.0%	+16.7%	1.9	23.0%	+22.4%	2.2
India	11.2%	-7.7%	-2.6	16.0%	-10.5%	-2.3

Iran	0.4%	-0.4%	-4.6	0.6%	-0.6%	-4.3
Rest of the World	2.7%	-2.7%	-6.6	3.9%	-3.9%	-6.2
South Africa	1.6%	-1.3%	-4.4	2.3%	-1.7%	-4.1

Source: Vivid Economics calculations

Table 31 The South Korean crude market with a fifteen per cent increase in bunker prices

	Initial	Final	Change	Initial	Final	Change
	Oil price $95 per barrel			Oil price $60 per barrel		
Size (million tones p.a.)	116.7	116.7	-0.03%	116.7	116.7	-0.05%
Price ($ per tonne)	696.6	697.8	0.16%	440.0	441.1	0.26%
Domestic market share	0.0%	0.0%	0.00%	0.0%	0.0%	0.00%
Land-based market share	0.0%	0.0%	0.00%	0.0%	0.0%	0.00%
Sea-based import market share	100.0%	100.0%	0.00%	100.0%	100.0%	0.00%
Average added cost for sea importers ($ per tonne)		1.03			1.03	
Cost pass-through for sea importers		110.9%			111.5%	

Source: Vivid Economics calculations

Table 32 The US crude market with a fifteen per cent increase in bunker prices

	Initial	Final	Change	Initial	Final	Change
	Oil price $95 per barrel			Oil price $60 per barrel		
Size (million tones p.a.)	742.8	742.8	-0.01%	742.8	742.7	-0.01%
Price ($ per tonne)	696.6	696.9	0.04%	439.9	440.3	0.06%
Domestic market share	36.9%	37.0%	0.04%	36.9%	37.0%	0.09%
Land-based market share	49.5%	49.5%	0.06%	49.5%	49.6%	0.12%

Sea-based import market share	50.5%	50.5%	-0.06%	50.5%	50.4%	-0.12%
Average added cost for sea importers ($ per tonne)		$0.36			$0.36	
Cost pass-through for sea importers		72.6%			73.5%	

Source: Vivid Economics calculations

Table 33 Market share and margin changes in the US crude market with a fifteen per cent increase in bunker prices

Supplier	Original market share	Change in market share in percentage points	Change in sales in the US	change in margin ($/tonne)
US	36.9%	0.0	0.2%	0.3
Canada	12.5%	0.0	0.3%	0.3
Other Americas	20.9%	0.0	0.2%	0.1
Middle East	11.7%	0.0	-1.0%	-0.5
Africa	13.9%	0.0	-0.3%	-0.1
Other	4.0%	0.0	-0.4%	0.0

Source: Vivid Economics calculations