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# Global route choice and its modelling of dry bulk carriers based on vessel movement database: Focusing on the Suez Canal

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ABSTRACT

This paper addresses global route choices for dry bulk carriers, focusing on the competitive situation between the Suez Canal (SC) and its competitors, such as the Panama Canal (PC) and the route via the Cape of Good Hope. The authors first establish a methodology and estimate the actual route choices for dry bulk carriers based on a vessel movement database, focusing on the share of SC transit for each pair of regions where the cargo originates and is destined to. Second, an aggregated logit model is applied to predict the estimated shares by regional pair and is utilised in sensitivity analyses for simulations that consider the recent changes in the dry bulk shipping market such as the PC's expansion, the decline in bunker prices, and the suppression of Somali piracy risk. The results suggest that the proposed methodology is useful for estimating the share of SC transit by regional pair and that the model for describing route choice is validated through not only output indices such as prediction rate but also sensitivity analyses, a time transferability check, and a comparison with the results of a shortest-path model.

## 1. Introduction

Globalisation is connecting vessel traffic around the world. For example, a dry bulk carrier will ship to any area of the world it is ordered to go to. As maritime shipping becomes globalised, competition among shipping routes becomes more severe. The Suez Canal (SC), located in the Arab Republic of Egypt, is also being exposed to intense global competition. The SC is an artificial waterway about 194 km long connecting the Mediterranean and Red seas. It was opened in 1869 by a French company and taken under the state control of the Egyptian government in 1956. Despite several closures due to war, it has served as a critical infrastructure for global maritime shipping (especially for trade between Europe and Asia) since its reopening in 1975. The 'New Suez Canal', an expansion project, was completed in August 2015. However, while the project reduced transit time through the SC, size restrictions on vessels remain unchanged, as does the maximum daily number of vessels that can transit the SC. This differs from the Panama Canal (PC), which was expanded in June 2016.

Shibasaki, Azuma, and Yoshida (2016) analysed the SC's current competitive situation in terms of containerships and applied an aggregated logit model to describe the route choices of shipping companies on a global scale. Containerships represented the largest portion of SC transit in terms of both number of vessels and vessel capacity, as Table 1 illustrates. However, other types of vessels – namely tankers (shipping liquid bulk cargo) and bulk carriers (shipping dry bulk cargo) – are also important for the SC and account for non-negligible portions, as Table 1 also shows. This study focuses on dry bulk carriers; a similar analysis and model application will be conducted for other types of vessels, including tankers, in other studies.

The most significant difference between containerships and other types of vessels, including bulk carriers, concerns whether they are served on a regular or chartered basis, which directly affects data availability. Liner shipping can be compiled on a service-basis more easily than tramp shipping can. For example, Shibasaki et al. (2016) utilised the MDS containership databank, which provides information on global containership movement; it includes information on not only each vessel (e.g. vessel name, IMO number, carrier name, vessel capacity, vessel speed) but also each service (e.g. name of service, service frequency, category of service area, ports of call and their order), although no information on cargo contents or load factor is provided. Alternatively, only the vessel movement database is available for other types of vessels; details on the information available will be provided

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**Table 1**
Breakdown of Suez Canal transit by vessel type (as of 2015).
Source: Suez Canal Authority (2016).

| Type | Number of vessels | | Capacity | |
|---|---|---|---|---|
| | No. | Share | Amount (1000 ton) | Share |
| Tankers (incl. LPG) | 4316 | 24.7% | 177,782 | 17.8% |
| LNG ships | 670 | 3.8% | 72,996 | 7.3% |
| Bulk carriers | 2878 | 16.5% | 102,156 | 10.2% |
| Combined carriers | 2 | 0.0% | 122 | 0.0% |
| General cargo ships | 1527 | 8.7% | 16,060 | 1.6% |
| Containerships | 5941 | 34.0% | 555,579 | 55.6% |
| RO/RO ships | 387 | 2.2% | 9046 | 0.9% |
| Car carriers | 939 | 5.4% | 56,927 | 5.7% |
| Passenger ships | 68 | 0.4% | 3292 | 0.3% |
| Others | 755 | 4.3% | 4692 | 0.5% |
| Total | 17,483 | 100.0% | 998,652 | 100.0% |

later. Therefore, it is more difficult to assess the current route choice of each vessel than for containerships.

A major competitor of the SC also differs from containerships. The SC's major competitor for containerships is the PC, mainly for the vessels connecting eastern Asia and the east coast of North America. The SC's major competitor for dry bulk carriers (and tankers) is the route via the Cape of Good Hope (hereafter 'Cape'). Table 2 illustrates the major export countries/regions by maritime shipping for three major dry bulk cargoes: iron ore, coal, and grain. Competition may occur mainly between the SC and the Cape route when European countries import these cargoes from Australia, Southeast Asia (including Indonesia), India, and the Middle East, or when Asian countries import from Europe and the east coast of North and South America.

This paper first establishes a methodology for estimating the route choice of dry bulk carriers for each pair of regions where the cargo originates and is destined to by utilising a vessel movement database. The authors estimate the SC transit share to evaluate how the SC competes with other routes in the dry bulk shipping market on a global scale. No study appears to have used a vessel movement database for such a global route choice analysis. Therefore, this estimation is as important a part of this paper as is the model application conducted in the latter half of this paper. Second, an aggregated logit model for predicting the shares of each route by regional pair is applied. Finally, the model is used to conduct several simulations, such as the expansion of the PC, the impact of fuel cost changes, and the reduction of the piracy risk off the coast of Somalia.

The remainder of this paper is organised as follows. In Section 2, we position this paper against the recent literature in the field. Section 3 presents an estimation methodology for route choice by utilising a vessel movement database and estimation results as of 2010 and 2013. Section 4 presents a model to predict route share; its reproducibility is then confirmed through a comparison with current route shares. Section 5 presents policy simulation examples using the model as a sensitivity analysis. Finally, Section 6 concludes the paper.

## 2. Literature review

Many recent papers have examined ship routing and scheduling models for bulk carriers (including tankers), as reviewed by Al-Khayyala and Hwang (2007), Christiansen, Fagerholt, Nygreen, and Ronen (2013), Fagerholt and Ronen (2013), Vilhelmsen, Lusby, and Larsen (2013), Vilhelmsen, Larsen, and Lusby (2014), and Lee and Kim (2015). Vilhelmsen et al. (2014) named this issue the 'tramp ship routing and scheduling problem' (TSRSP). The original TSRSP included a canal choice problem – for example, a tanker's choice between the SC or Cape route according to whether it is fully loaded or in ballast, respectively, as discussed by Brown, Graves, and Ronen (1987). However, many recent papers have focused on the vessel scheduling and allocation problem; only a few papers, such as Siddiqui and Verma (2015), explicitly consider route choices for bulk carriers that include canals on a global scale. Fu, Ng, and Lau (2010) developed a model that includes a detour in the shipping route (from the SC to the Cape route) by a shipping company and reduced shipping demand among shippers due to the piracy risk off the coast of Somalia. This simple but intriguing model considers the interaction between a shipping company and a shipper, although it focuses on the shipper's side to measure the economic impact of Somali piracy on international trade.

As stated in Shibasaki et al. (2016), most of the papers that focus on the global route choices of shipping companies, including competition for the SC, focus on the viability of the Northern Sea Route (NSR). Meng, Zhang, and Xu (2016) reviewed recent papers on the NSR. Among them, Schøyen and Bråthen (2011) compared the shipping costs and environmental impacts of the NSR and SC routes for bulk shipping, including mineral fertiliser and iron ore. Marucci (2012) compared among the $CO_2$ emissions for each major global shipping route, including the post-expansion PC, SC, the Cape of Good Hope, Cape Horn, and the land bridge of North America for several typical pairs of origin/destination ports. However, most of the research on route choices from a global perspective focuses on containerships. For example, Notteboom (2012) compared the SC and Cape routes; Fan, Wilson, and Denver (2009) and Ungo and Sabonge (2012) focused on the PC and the North American land bridge; Shibasaki et al. (2016) focused on the SC, PC, and Cape routes; and Tavasszy, Minderhoud, Perrin, and Notteboom (2011) and Ducruet (2016) examined all international routes but a

**Table 2**
Major exporters (in terms of maritime shipping) of major dry bulk cargoes as of 2013.
Source: IHS (World Trade Service data).

| Rank | Ores, iron, and manganese | | Coal | | Grains (corn, rice, soybean, wheat, and other grains) | |
|---|---|---|---|---|---|---|
| | Country/region name | Export amount (1000 ton) | Country/region name | Export amount (1000 ton) | Country/region name | Export amount (1000 ton) |
| 1 | Australia | 618,951 | Indonesia | 375,748 | United States | 90,369 |
| 2 | Brazil | 337,064 | Australia | 356,823 | Brazil | 66,634 |
| 3 | Southern Africa | 106,892 | United States | 100,170 | Argentina | 38,387 |
| 4 | Canada | 38,300 | Colombia | 81,834 | Australia | 27,495 |
| 5 | Other Western Africa | 24,843 | Southern Africa | 70,997 | Canada | 21,959 |
| 6 | India | 18,609 | Russia | 54,820 | Ukraine | 18,085 |
| 7 | Other Western Asia | 17,030 | Canada | 37,806 | Russia | 13,863 |
| 8 | Russia | 16,676 | Vietnam | 17,118 | India | 13,495 |
| 9 | Ukraine | 15,777 | China | 9292 | Other Southeast Coast of South America (Paraguay and Uruguay) | 12,447 |
| 10 | Indonesia | 13,980 | New Zealand | 2042 | France | 11,139 |
| World total | 1,303,972 | | 1,132,524 | | 353,322 | |