

## Shipping mode choice in cold chain from a value-based management perspective

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### ABSTRACT

The competition between bulk and containers in reefer shipping has become increasingly intensified in recent years. This study aims to investigate the modal choice between reefer bulk and container vessels by applying the value-based management tool in cold chain management. A value-based decision model is developed for operational and financial planning with Economic Value Added as the objective function. The commodity character and the voyage distance are identified as the main factors that affect the modal choice. The numerical study and sensitivity analysis reveal the change in modal choice and route choice under different operational and financial scenarios.

### 1. Introduction

Cold chain is a branch of supply chain which handles temperature sensitive products such as perishable food, confectionary and pharmaceuticals (George, 2000). Despite the current flagging economic environment, refrigerated trade continues to grow steadily due to people's increasing purchasing power and growing health consciousness (Lam, 2010). World refrigerated trade has reached 190 million tonnes by 2014 (Drewry, 2015). Half of the 190 million tonnes are shipped by sea, one of the two main modes of transportation for long-haul physical movement. While studies in maritime logistics piled in recent years, seaborne refrigerated trade has become an indispensable part of global ocean-going trade and an emerging discipline that has gained increasing attention among researchers (Lam and Bai, 2016). Since the ocean-ongoing trade plays an essential role in international trade and commerce, a better understanding and an in-depth study of the seaborne cold chain would provide valuable insights for international trade and commerce development strategy.

Selection of the transportation mode is a crucial decision in logistics management as different modes may affect the effectiveness of the logistics performance, contribute differently to the cost structure and lead to different economic performance (Meixell and Norbis, 2008). Mode choice is a decision-making process involving transportation performance variables identification, mode selection, contract negotiation, and carrier performance evaluation (Monczka et al., 2005). As more and more criteria have been involved, the selection has become increasingly complex. Numerous approaches and models such as simulation (deJong and Ben-Akiva, 2007) and discrete choice models (Garrido and Leva, 2004), aiming at different objectives like minimizing cost and transit time or even limiting carbon emission (Chen and Wang, 2016), have been applied to facilitate such decision making. Despite a wide range of studies in transportation mode choice, none has investigated such selection in the context of cold chains, in which the primary criteria – cost and transit time – are more closely correlated. This study aims to bridge this gap by starting with a specific problem, the choice between different reefer vessels in seaborne cold chains from a value-based perspective. The theoretical tool, value based management, is applied for the first time in mode choice studies to address the multi-attribute and multi-objective

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characteristic.

Over the last two decades, seaborne shipments of perishable commodities have expanded and changed tremendously (Arduino et al., 2015). Full reefer bulk vessels and reefer container – a special sea-freight container well equipped to control inside temperature and air flow – are the two main groups of reefer fleet (Bömer and Tadeu, 2014). The share of reefer cargoes carried by traditional specialized bulk vessels has been gradually eroded by the containership fleet (Rodrigue and Notteboom, 2015). The competition between bulk and containers in terms of reefer cargoes becomes increasingly intensified. Although the reefer container fleets grow massively due to numerous economic and technological factors (Penfold, 2000), advantages of bulk vessels remain strong for certain commodity flows (Arduino et al., 2015). Banana serves as a good example, which becomes the most traded reefer commodity as well as the most shipped seaborne reefer cargo (Drewry, 2010, 2011) since a century ago when the first reefer ship for banana weighed anchor in 1902 (Rodrigue, 2014). Although the reefer container fleets erode the reefer market share of the traditional reefer bulk, the reefer bulk remains the main shipping method of banana and the shippers are reluctant to change. Scholars began to pay attention to this issue (Arduino et al., 2015; Rodrigue and Notteboom, 2015; Thanopoulou, 2012), however, most of these studies are based on qualitative analysis. This paper approaches this issue from the value-based perspective and provides a decision model for shippers to maximize their value creation by balancing the utilization of refrigerated bulk and container vessels. The model is based on value-based management and drills down the shareholder value into decomposed operational factors. It covers both the operational and financial aspects of seaborne shipment.

Unlike other supply chain performance management models, value-based approaches avoid the two major weaknesses of other decision tools: 1. not supporting conflicting performance metrics; 2. lack of insights into interdependencies and cause-and-effect relationships among the metrics (Cai et al., 2009). Value-based management applies value driver trees and risk adjusted performance metric for performance and risk management, and it adopts only one paramount performance metric which can simultaneously manage both financial and operational decisions for value creation (Young and O’Byrne, 2001). The advantage of value-based optimization comparing with conventional optimization methods is further demonstrated and quantified in this study. A variety of indicators have been adopted to indicate value-based performance, Economic Value Added (EVA) is more powerful than other traditional tools to measure business performance and to express a value judgement on the company (Melis et al., 2014). Lambert and Burduroglu (2000) compares the advantage and disadvantage of EVA with other five value metrics, namely, customer satisfaction, customer value-added, total cost analysis and segment profitability. Lambert and Burduroglu (2000) concluded that EVA, which derives the total shareholder value, is the most comprehensive measure for the value of logistics. Therefore EVA is adopted as the indicator of value-based performance in this study and an EVA value driver tree is proposed to analyze the value drivers in a seaborne cold chain.

The rest of the paper is structured as follows. Section 2 reviews recent studies in seaborne cold chain as well as in value-based supply chain management. The value drivers in seaborne cold chain are introduced in Section 3 and a corresponding decision model is proposed in Section 4. Section 5 illustrates the model with a numerical example, followed by the sensitivity analysis and implications in Section 6. Finally, Section 7 summarizes the research’s contribution, discusses the limitations of this study and shares an outlook for future work.

## 2. Literature review

### 2.1. Seaborne cold chain

As a niche area in supply chain management, cold chain started to gain attentions in both the industry and academia due to its

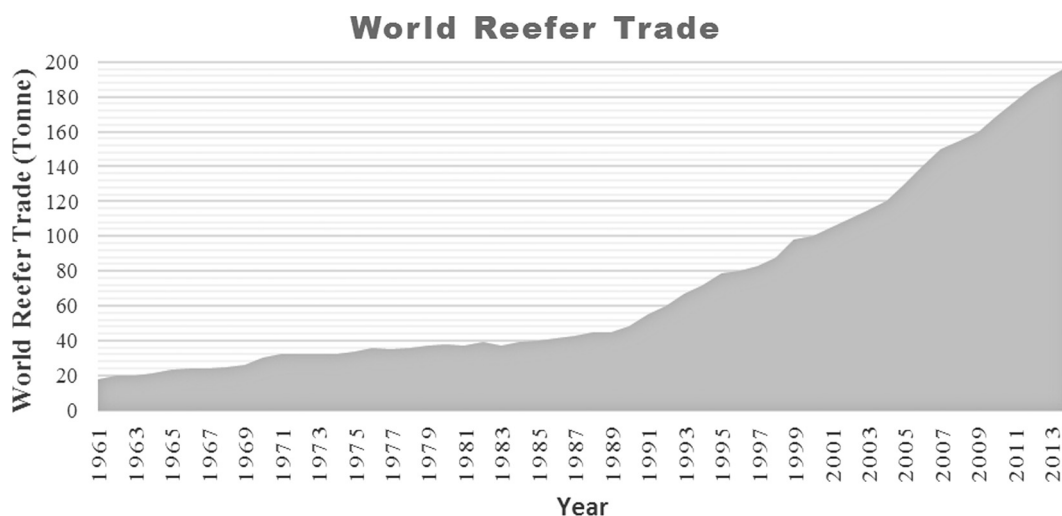


Fig. 1. World reefer trade in tonnes. Source: Authors’ compilation based on Nomadic Shipping ASA (2002), and Drewry (2015).

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