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Reprint of "Enhancing green supply chain initiatives via empty container reuse" ☆

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ABSTRACT

In this paper, the maritime industry's commitment to green supply chain has been analyzed. The objective of this study is to show that the reuse of empty containers not only adds value to a firm, but leads to waste reduction in the supply chain. The novelties of this article include (i) empty and laden containers are treated in accordance with a shipping company's green effort; (ii) both the volume and weight of containers are introduced to indicate a potential constraint on green effort; (iii) empty container storage costs are included as a value-added component which stem from green effort.

1. Introduction

Effective supply chain management has long been recognized as an important source of competitive advantage. Increasingly, green supply chain initiatives have been recognized by forward thinking companies as being critical to sustaining this competitive advantage. Evidence of this recognition can be found in the publication of corporate sustainability reports that are distinct from prototypical corporate annual reports (World Shipping Council, 2011). Greening the supply chain requires that supply chain partners collaborate to ensure environmental, social and ethical compliance across the entire supply chain both upstream toward raw material resources and downstream in the direction of the individual consumer. Many authors (Ageron et al., 2012; Li, 2012; Sheu and Talley, 2011; Sheu and Chen, 2012) have indicated that such green collaboration can only be achieved through a substantial commitment of resources and deployment of organizational capabilities. The fundamental goal of green supply chain management is to ensure that the current supply chain's consumption of natural resources is sustainable and does not compromise the ecological systems that sustain life.

Maritime transportation, which accounts for about 80% of world merchandise trade by volume, is the backbone of international trade (UNCTAD, 2012). An ever-expanding share of this import and export volume is moved using containerized shipping which was designed to improve transportation productivity and reduce the incidence of damage associated with loading and unloading cargo (Francesco et al., 2013; Sheu and Talley, 2011). Due, in part, to the efficiencies generated through the use of container boxes global seaborne trade has grown steadily and reached a record high of 8.7

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billion tons in 2011 (UNCTAD, 2012). Trade volume, however, is not balanced. In the Trans-Pacific trade, for instance, the container flow from Asia to North America is much higher than that from North America to Asia. As a result, some ports accumulate empty containers while others encounter a container shortage problem (Francesco et al., 2013). The accumulation of empty containers near the ports in some US coastal cities have taken on the appearance of tall buildings. At any given moment in time millions of empty containers sit unused at locations around the world. The global fleet of container equipment was estimated to be 18.605 million units, or 28.535 million twenty-foot equivalent units (TEUs), in 2011 (World Shipping Council, 2011). The ratio of box-inventory-to-vessel capacity fluctuates over time; however, it was estimated that by the end of 2011 it would be approximately 1.99, the lowest on record. This is considered an unusually low value given the ratio was as high as 2.99 boxes per slot in 2000, and is purported to be an indicator of a container shortage (Alphaliner, 2011). This suggests that even in a period of potential container shortage that any given point in time over 14 million TEUs were not on container vessels during the time period. Many of these containers, clearly, sat empty as they awaited redeployment.

Empty containers that sit empty represent an underutilized inventory of capital equipment and pose environmental hazards. Machalaba (2001) reported that at a Newark container-storage facility a heavy storm caused seven empty containers to be damaged as they toppled off their stacks. Damaged containers must be repaired or, if the damage is irreparable, replaced. In the case of irreparable damage the effected container must be disposed of via an appropriate disposal channel and method. In either event there is a net cost to the environment related to the consumption of raw materials and energy. Events such as the one described by Machalaba (2001) are, if not prevalent, not rare. Arguably, the greater environmental costs associated with empty containers involve the need to reposition them. Clearly, carbon emissions are generated in this activity when container yard equipment is used to move empty containers, trucking equipment is used to move unused equipment to storage facilities, and container vessels are employed to move empty containers between ports. Container ships use low grade bunker fuels that lead to significant levels of carbon dioxide, nitrogen oxide, and sulfur oxide pollution. Systematically managing and repositioning empty containers has the potential to contribute to the greening of the supply chain through improved environmental performance and waste reduction while simultaneously improving the bottom-line performance of shipping companies (Shi et al., 2012).

The adoption of green management practices is an increasingly integral element of policy planning and a major strategic thrust for business organizations. This calls for a new approach to conducting business, from merely achieving economic profit to developing ecologically sensitive strategic management policies. Green enterprises are developed through a variety of approaches such as utilizing eco-efficiency methods in product design or establishing recycle, reuse, refurbish, and re-manufacturing systems. In the maritime industry, green initiatives can include a diverse set of initiatives such slow steaming, the use of technologically advanced hull coatings, and empty container repositioning. While green supply chain initiatives are becoming more pervasive in the maritime industry they have not yet been adequately, or explicitly, analyzed and discussed in the literature. We address a portion of this gap between the maritime industry's interest in green supply chain initiatives and academic inquiry by considering the empty container repositioning problem through the lens of pertinent environmental factors. The objective of our study is to show that appropriately developed policies for reusing empty containers can add value to a firm, reduce waste in the supply chain, and green our environment.

The latest iteration of green supply chain management refers to the firm's responsibility to ensure the environmental and social compliance of the chain by coordinating the actions and behaviors of its upstream and downstream members. As argued earlier, empty shipping containers represent a prime environmental concern that are particularly challenging to manage. Extensive information sharing and collaboration across multiple supply chain stakeholders must occur to achieve green supply chains. For example, ports with empty containers must be identified and routes selected. Vessel loading requires that the weights and volumes of both laden and empty containers are balanced. All of these decisions require a high level of collaboration among shipping companies and ports that are located in geographically diverse parts of the world.

This research develops an optimization model for reusing empty containers in order to enhance green supply chain collaboration between ports. The model is used to address three fundamental questions: (1) How should ports possessing empty and laden containers be selected? (2) How can the weight and volume constraints of vessels be balanced when loading a mix of laden and empty containers? and (3) How can the value of reusing empty containers that stems from green supply chain collaboration between ports be measured? The purpose of this study, ultimately, is to maximize the value in the planning horizon to the green supply chain by collaboratively reusing empty containers and transporting laden containers. In this study, the value of green supply chain effort is measured using the revenues generated from transporting laden containers, reusing empty containers, and reducing storage expenses at ports where empty containers accumulate.

The remainder of this article is arranged as follows. Section 2 presents a brief overview of the extant literature related to the empty container repositioning problem. We begin Section 3 by characterizing the container repositioning problem as it is addressed in this research. The primary model assumptions and the model itself are then presented. Next, the model is illustrated and the results of sensitivity analyses are presented in Section 4. Section 5 offers an examination of the managerial implications revealed in the research and our conclusions are presented in section six.