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Productivity growth, scale economies, ship size economies and technical progress for the container shipping industry in Taiwan

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ABSTRACT

Rather than adding up all cost items of ship operation in the traditional vessel-based approach, this paper develops a theoretical model to evaluate and decompose the total factor productivity (TFP) growth of the container shipping industry in Taiwan. The results show that scale economies and ship size economies play the dominant roles in improving TFP growth. Since 2006, the dominance of TFP growth has gradually shifted from scale economies to ship size economies. This finding reconfirms the cost advantage of large vessels. In addition, it indicates that the deployment of large vessels has led to a problem of serious over-capacity.

1. Introduction

In the global liner shipping industry, containerization has revolutionized and significantly reduced the cost of the marine transportation of general cargo due to the great improvement in operational efficiency. In particular, the structure and environment of the international container shipping industry have experienced tremendous change that has resulted in the major container shipping lines eagerly deploying large containerships and operating through strategic shipping alliances with space-sharing (vessel-sharing) and slot chartering activities (Alix et al., 1999; Cullinane and Khanna, 2000; Talley, 2000). As a result, the increasingly concentrated industry has become dominated by a small number of global shipping alliances operating more intensified service networks. However, the trend among the major container shipping lines toward the aggressive deployment of large containerships has given rise to an industry-wide problem of underutilized fleet capacity, regardless of the overwhelming cost advantage derived from having a fully-loaded large containership. On account of the changes in the container shipping industrial environment, it is worth clarifying the impact of delivering large containerships on the productivity growth of shipping lines.

Alternatively, rising oil prices and record-low interest rates, especially over the past decade, have also encouraged container shipping lines to aggressively expand their fleet capacity and adopt the best-practice technical and managerial processes. Followed by the emergence of shipping alliances, the technology and skills fora shipping line operating and managing a steadily growing containership fleet have changed correspondingly (Talley, 2000; Wu and Lin, 2014). Alongside the rapid expansion of the fleet capacity deployed, meanwhile, the container shipping industry has also achieved a several-fold increase in cargo shipments since more and more international business opportunities have been created by the flourishing global free trade during

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the past decade. With the changes in the level of factor inputs, output and relative input prices, the growth in productivity as the result of operating a vessel fleet has definitely been altered, but the productivity gain is still unknown.

Total factor productivity (hereafter, TFP) has been developed to measure the productivity growth of a firm or industry with multi-output and multi-input production. Methodologically, the TFP approach is based on the theoretical properties derived from production or cost functions to investigate the productivity growth of the firms/industries studied. Unlike the measure of productivity based on a single factor input, such as labor productivity, Daly and Rao (1985) demonstrate that TFP is the best single measure of economic efficiency that is exempt from the influence of inter-factor substitution induced by changes in relative input prices. However, TFP is not an unambiguous concept either in theory or in terms of practical measurement (Oum et al., 1992; Waters, 2008). Furthermore, Barro (1999), Mahadevan (2003) and Hulten (2001) also present a large number of controversial points about the concept, measurement and interpretation of TFP growth. By definition, the TFP index is the ratio of an aggregate output quantity index to an aggregate input quantity index. Because of the aggregation problems inherent in multi-output and input production, various approaches to computing the aggregate indices of inputs and outputs may lead to different TFP growth rates. As a consequence, different interpretations and empirical results may be derived from studies (Diewert, 1992).

In addition, some studies have also presented theoretical derivations and empirical evidence to show that the TFP growth rate can be further decomposed into a variety of components. Identifying and estimating the components of the TFP growth rate will provide further insights into the impacts of output growth, institutional regulation, and technical change as firms evolve over time. Denny et al. (1981) analyze the productivity growth by decomposing the TFP growth rate into different components. Furthermore, Hooper and Hensher (1997) apply a non-parametric index approach to measure the TFP of Australian airports and divide the sources of productivity differences among airports based on scale effects and managerial performance. Meanwhile, by focusing on different industries, many empirical studies follow a similar approach in decomposing the TFP growth rate to investigate the major sources of productivity growth (Lee et al., 1999; Callan, 1986; Gollop and Roberts, 1983; Caves et al., 1981).

This paper is motivated by the following observations. In the literature, most of the maritime-related research that explores operational efficiency or productivity growth is mainly focused on port and terminal operations (Talley, 1994; Liu, 1995; Notteboom et al., 2000; Tongzon, 2001; Barros, 2003, 2006; Cullinane et al., 2006; Cullinane and Wang, 2006; Rios and Macada, 2006; Cheon et al., 2010). As part of a sea-transport chain, the efficiency of shipping lines is equally important to the efficiency of seaports that provide the sea–land interface. Despite the importance of the container shipping sector in marine transportation, existing studies devoted to investigating the productivity growth in the container shipping industry have been surprisingly limited.

On the other hand, studies related to the operational efficiency of container shipping lines are usually vessel-based when it comes to analyzing the cost efficiency of vessels with different sizes. Meanwhile, sensitivity analysis that compares different total operating costs with respect to different operational conditions, such as ship size, the number of ports of call, sailing frequency, and voyage distance, is often applied to determine the optimal ship size (Jansson and Shneerson, 1982; Lim, 1994, 1998; Talley, 1990; Cullinane and Khanna, 1999, 2000). Therefore, data at the vessel-level rather than at the firm-level are mainly used in such studies.

By contrast, Panayides et al. (2011) is one of very few studies in the literature to examine the relative efficiency of shipping firms by utilizing a set of financial data covering 26 firms from the container, bulk and tanker sectors. Their study also mentions that the limited attention given to investigating the operational efficiency of shipping lines implies that the variables and measures that may be used as inputs and outputs in the models have not been well developed. In addition, Klein and Kyle (1997) also point out that there have been only a few attempts to apply modern econometric methods to investigate the efficiency performance of the shipping industry due to the difficulty in obtaining data. Obviously, concerns over releasing confidential commercial data to the public is still the main reason why it is difficult for researchers to collect operational data from container shipping lines, and why such research has often been infeasible.

In recognizing the distinct lack of an efficiency measurement for container shipping lines as opposed to the seaport sector, this paper aims at providing an assessment of the productivity growth of container shipping lines and filling the gap in the literature. Differing from the traditional vessel-based studies that relied heavily on the assumptions regarding the conditions of shipping operations, this study applies TFP growth by using firm-level data to investigate the productivity growth in the container shipping sector. By collecting financial and operational data from shipping lines and following with a specified cost function, the goal of this study is to measure TFP growth and clarify the sources of such growth for the container shipping industry in Taiwan.

Based on the theoretical derivation of Divisia TFP growth, this paper makes a contribution to the measurement of productivity growth by engaging in an assessment and decomposition of TFP growth for the container shipping industry in Taiwan. In sum, the main contributions of this paper are as follows:

(1) Although there are a number of studies related to exploring the operational efficiency or productivity growth of maritime transportation, most of them focus on port and terminal operations. In our review of the related literature, we do not find any studies that are focused on exploring the operational efficiency or productivity growth of container shipping lines. This paper therefore develops a model with a solid theoretical foundation to evaluate and decompose the productivity growth of container shipping lines. In objective terms, this study enhances the theoretical foundation of empirical research in the maritime-related literature.