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Revisiting port performance measurement: A hybrid multi-stakeholder framework for the modelling of port performance indicators

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ABSTRACT

This study develops a new port performance measurement model by taking the perspectives from different port stakeholders. The novelty lies in the modelling of interdependencies among port performance measures, and the combination of weights of interdependent measures with both qualitative and quantitative evaluations of the measures from multiple stakeholders for quantitative port performance measurement. It represents an effective performance measurement tool and offers a diagnostic instrument for performance evaluation and/or monitoring of ports and terminals so as to satisfy different requirements of various port stakeholders in a flexible manner.

1. Introduction

Seaports (hereinafter called 'ports') are key nodes in global logistics networks and contribute to the efficiency of global supply chains. Changes in supply chain management force ports (and terminals) to seek effective integration in supply chains when delivering value to shippers and third-party logistics service providers (Robinson, 2002; Mangan et al., 2008; Song and Panayides, 2008). Ports are thus parts of complex systems operating in an uncertain logistics environment. They are also places where stakeholders provide products and deliver services that create value. The interests of different port stakeholders, i.e., port authorities, port users, service providers and related communities, in economic, social, and environmental issues, are sometimes in conflict (Notteboom and Winkelmans, 2003). Port managers increasingly rely on stakeholder relationship management practices to secure long-term relations with key stakeholders (Dooms and Verbeke, 2007). To this end, port performance measurement (PPM) becomes an important tool in stakeholder relationship management and to achieve a sustainable competitive position.

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Over the past decades, PPM has become a well-established segment in port-related academic literature (see Pallis et al., 2011 and Woo et al., 2012) but there are still significant research gaps yet to be filled. First, the existing literature tends to focus on limited dimensions of PPM or specific areas of ports. Such a fragmented approach fails to take into account new issues and challenges faced by ports. The extant relevant literature primarily introduces lists of port performance indicators (PPIs) to measure the productive and allocative efficiency of port/terminal operations (i.e., operational efficiency), focusing on terminal quayside operations via the application of, say, data envelopment analysis (DEA) and stochastic frontier models (Tongzon, 1995; Cullinane et al., 2002; Talley, 2006; González and Trujillo, 2009). Compared to port efficiency studies, existing studies on port effectiveness (e.g., Brooks, 2006; Brooks and Schellinck, 2013) are mostly restricted to the dimension of customer satisfaction using qualitative PPIs (i.e., service effectiveness). In this regard, PPM should consider the different natures of PPIs. Using only quantitative PPIs is not sufficient to measure and diagnose performance (Beamon, 1999).

Second, there are few studies available on the development of a systematic approach to address the multi-stakeholder dimension in PPM. PPM demands a stakeholder-driven approach to cover the wide-ranging objectives and desired results of stakeholders. This can be achieved through integrating a multi-stakeholder dimension in a PPM framework which takes into account the corresponding PPIs. These stakeholder-specific PPIs need to be aligned with organisational goals and strategies (Neely et al., 1995; Kaplan and Norton, 2004) and present a clear picture of the organisational performance (Gunasekaran et al., 2001). Moreover, the range of port activities that port stakeholders are concerned with requires a focus on a multi-dimensional set of quantitative and qualitative PPIs. The use of only a single dimension (e.g., financial measures) is not sufficient to cover all related issues in the contemporary business environment (Miller and Vollmann, 1985; Fry and Cox, 1989). The importance of non-financial (i.e., intangible assets) measures and the integral application of multi-dimensional measures (i.e., both financial and non-financial measures) for performance measurement have been continuously acclaimed (Neely et al., 1995). Thus, there is a need for a multi-dimensional PPM approach evaluated by different stakeholders. Evidential reasoning (ER) (Yang and Xu, 2002) is proven to be a powerful method for multi-group multi-criteria decision making (MCDM). The method has been applied in the context of port choice to deal with the associated inherent uncertainty in a MCDM structure (Yeo et al., 2014). Although the study of Yeo et al. (2014) has its merits, it does not address PPIs from multiple dimensions/perspectives, it does not well evaluate PPIs from various stakeholders, and it does not appropriately incorporate the interdependency among PPIs.

The research gaps identified above call for the development of a systematic framework that can answer the questions of ‘what to measure’ and ‘how to measure port performance’. Such a PPM framework does not only meet the needs of port stakeholders, but also enriches the diagnostic tools available to support decision-making in complex port/terminal systems operating in an uncertain environment. The aforementioned ER approach has shown its capability of combining evaluations of different natures (quantitative and qualitative) from stakeholders (Yang et al., 2009) having different or even conflicting perspectives on a particular PPI. This framework needs to involve multiple dimensions with both quantitative and qualitative PPIs so as to offer diagnostic instruments to decision makers. ER can assist the proposed framework to analyse port measurement results with respect to a single performance indicator, dimension or stakeholder. The decisions are usually made on multiple uncertain attributes, for instance, situations where historical data is not available or seriously inadequate for qualitative performance indicators. Consequently, this study deals with the inherent data uncertainties which are sometimes unavoidable in port/terminal operational contexts. Fuzzy logic (Zadeh, 1978) is proven to be suitable for modelling vagueness or fuzziness caused by subjective judgements (e.g. evaluation of qualitative PPIs in this study).

Furthermore, the framework needs to identify interdependencies among the PPIs. Given the complexity in port activities and operations, decision makers require an essential understanding of the interdependency among the PPIs and develop appropriate solutions to improve port performance. Traditionally, analytical network process (ANP) (Saaty, 1996) is used to configure the dependency among factors influencing a decision problem. However, it is observed that the application of ANP typically demands large data inputs for pairwise comparisons. To tackle this, we use a decision making trial and evaluation laboratory (DEMATEL) tool (Gabus and Fontela, 1973) to identify the PPIs of significant dependencies before using ANP to quantify such interdependencies.

The remainder of the paper is structured as follows. In the next section, the proposed port performance measurement (PPM) framework is outlined. The identification and description of the selected PPIs are described in detail in Section 3. In Section 4, a case study on performance of four Korean container ports is conducted using the newly proposed framework and a hybrid approach of fuzzy ER (i.e. FER) with DEMATEL and ANP. Finally, the paper concludes with a discussion of the results, the business and academic implications and recommendations for further research.

2. A conceptual discussion on the port performance measurement (PPM) framework

The research question focuses on ‘how to develop a PPM framework as a diagnostic instrument to assist decision makers in evaluating port performance?’. The objective of the proposed PPM framework is to identify the most crucial PPIs for each group of port stakeholders and to develop a powerful performance measurement tool. Various aspects such as uncertainty and interdependency among the PPIs are considered in the framework to deliver a more practical application in PPM. As illustrated in Fig. 1, the needs of different stakeholders were investigated in the first phase and their associated PPIs were derived in the second phase. To this end, we identify stakeholders’ goals and objectives in major (container) ports, and dis-