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Performance measurement system and strategies for developing low-carbon logistics: A case study in China

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ABSTRACT

With increasing global warming and environmental degradation, green and low-carbon development mode has being more and more widely accepted in the world. The lack of performance measure system (PMS) and unknown development strategies in the low-carbon context hinder the development low-carbon logistics in China. Motivated by this, our research investigates some important issues in developing low-carbon logistics. Based on the triple bottom line framework, a general PMS with 42 indicators from 12 dimensions is developed for evaluating the low-carbon logistics by using the method of multiple-case study and literature analysis. Eight representative and leading logistics enterprises from different logistics sub-sectors in the western China are selected as case enterprises. The barriers and strategies for developing low-carbon logistics are then identified based on 6 propositions. The barriers include the lack of low-carbon awareness, the inconsistency and incompleteness in policies and regulations, the scarcity of qualified logistics professionals, the unreasonable infrastructure and facilities, the low efficiency in logistics operations management, and the disordered transport modes. Effective coping strategies are proposed to deal with these barriers from the 6 perspectives based on the case study. We argue that if these strategies can be implemented well, low-carbon logistics can be developed well in China.

1. Introduction

The increasing global warming and environmental degradation has aroused widespread concern in the world (Root et al., 2003; Xue et al., 2017). Various measures have been taken to slow down global warming and environmental degradation, including developing low-carbon economy and using renewable energy resources (Boroojeni et al., 2016; Amini et al., 2017). Developing low-carbon economy, characterized by low emission, low pollution and low energy consumption, has become the consensus of the world (Liu et al., 2011), which is not only the focus of the construction of ecological civilization, but also the inevitable choice to achieve sustainable development of economy and human society.

Logistics, as one of the most important economic activities, plays a crucial role in the low-carbon development since it leads to some significant issues about energy consumption and carbon emissions (McKinnon, 2010a,b). In 2014, greenhouse gas emissions from transportation accounted for about 26% of the total U.S. greenhouse gas emissions, making it the second largest contributor in U.S. after the Electricity sector (USEPA, 2016). Therefore, low-carbon logistics has attracted more and more attention from enterprises and administrative authorities, and reducing energy consumption and carbon emissions has become the inevitable trend for the logistics industry (Fahimnia et al., 2015). From the macro perspective, developing low-carbon logistics is helpful to constitute a sustainable low-carbon economy system together with low-carbon manufacturing and low-carbon consumption (Halldórsson and Kovács, 2010; Pan et al., 2011). From the micro perspective, it is helpful to help logistics enterprises save energies and reduce emissions, and improve market competitiveness (Tang et al., 2015; Guo et al., 2016).

To develop low-carbon logistics better, we must know how to measure logistics operations performance (e.g., efficiency, productivity, cost) in the context of low-carbon and sustainable development by an effective performance measurement system. Performance measurement is an analysis process of evaluating how

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well organizations are managed and the value they deliver for customers and other stakeholders (Moullin, 2007), which involves a set of calculation, observation and consulting methods. It molds the behavior of not only the managers charged with the responsibility of developing competitive and operating strategies but also the operators who implement the strategies (Fawcett and Cooper, 1998). An effective PMS is crucial to achieving the performance measurement objective, which should be practical, reliable, easy to measure, comparable to other PMSs, and cost-efficient. It can also provide feedback to focus on individual or team performances and data for correction and improvement (Dumond, 1996). However, it is still open how a PMS should be established to evaluate the performance of logistics enterprises in the low-carbon and sustainable context. Moreover, it is very helpful for logistics enterprises to improve the logistics performance more smoothly in low-carbon and sustainable context if the main barriers and coping strategies for developing low-carbon logistics are known. However, they are still open and have not been analyzed and identified. The lack of PMS and unknown development strategies in the low-carbon context hinder the development low-carbon logistics in China.

Motivated by the two research requirements above, this research thus aims at answering two research questions, including (1) how should a general PMS be established to evaluate the performance of logistics enterprises in the low-carbon and sustainable context from the perspective of the whole logistics industry, and (2) what are the main barriers and strategies for developing low-carbon logistics. A case study will be conducted from multiple representative logistics enterprises in China. In the low-carbon and sustainable context, it is critical to measure the operational performance of the logistics enterprise from economic, social and environmental perspectives over a period of time. It is well-known that the famous triple bottom line (TBL) framework was proposed by Elkington (1998) to help the industry and the society to achieve the sustainability from these 3 perspectives. The TBL framework is thus adopted as the foundation for the PMS of low-carbon logistics in this research. The contributions of this paper include that (1) a TBL-based PMS is developed for evaluating low-carbon logistics, and (2) key barriers and coping strategies are identified for developing low-carbon logistics.

The rest of the paper is organized as follows. We conduct in Section 2 a comprehensive literature review on relevant previous studies. The methodology used is presented in Section 3. Afterwards, the PMS for low-carbon logistics is proposed in Section 4. The barriers and strategies for developing low-carbon logistics are identified and presented in section 5. Finally, we conclude with a discussion of future research in Section 6.

2. Literature review

2.1. Previous studies on PMS in logistics

PMS has become a research issue both in academic and industrial sectors since the end of the 1980s (Van Donselaar et al., 1998; Gutierrez et al., 2015). A variety of PMSs have been developed and adopted to measure the performances in extensive real-world operations (Kaplan and Norton, 1996; Plant et al., 2003; Nsamzinshuti et al., 2014; Schiffling and Piecyk, 2014; Sainaghi et al., 2017). Nevem working group (1989) presented four major indicators for logistics performance measurement: delivery time (delivery cycle), delivery reliability, delivery flexibility and inventory levels. These indicators only considered logistics performance from the perspectives of service and quality, but neglected the logistics cost. Frazelle (2002) provided a methodology for the determination of the indicators of logistics PMS, which measured the logistics performance from four perspectives, including finance, productivity, quality and reaction time. McKinnon (2010a,b) presented a framework for the decarbonization of their logistical activities based on five key freight transport indicators: freight transport intensity, modal split, vehicle utilization, energy efficiency and the carbon intensity of the energy used in logistics. Bowersox et al. (2012) pointed out that the logistics performance was evaluated generally from internal and external perspectives, internal performance indicators (PIs) usually involve cost, customer service, productivity indicators, asset evaluation and quality while external PIs usually involve the customer sense evaluation and the best practice benchmarks.

To the best of authors' knowledge, few studies on logistics PMS have considered the context of low-carbon and sustainable logistics, which involve environment- and social-related indicators. Autry et al. (2013) have presented some PIs for green ports and evaluated three major ports' overall green performance in Asia based on literature analysis and brain storming with academicians from China. Björklund and Forslund (2013) examined the purposes of having an environmental PMS in logistics and investigated in what ways the purpose of an environmental PMS could influence its focus in the supply chain based on a survey of shippers and logistics service providers in Sweden. They found that enterprises seem to design their environmental PMS mainly out of internal management purposes. Recently, Lee and Wu (2014) considered economic and environmental performance in PMS by taking a multi-methodological approach for address sustainability challenges in logistics and supply chain. However, no research has considered the social performances in logistics with economic and environmental performances together. To achieve low-carbon and sustainable logistics, it is very important to consider environmental, economic, and social performances simultaneously, according to the famous TBL principle (Hubbard, 2009; Assaf et al., 2012; Nikolaou et al., 2013; Meixell and Luoma, 2015; Gou and Xie, 2016).

2.2. TBL in PMS

The TBL framework has been applied in a variety of fields for a plenty of purposes since it was proposed in 1998 (Elkington, 1998). Some enterprises recognized that aligning with nonprofit organizations makes good business sense, particularly those nonprofit organizations with goals of economic prosperity, social well-being and environmental protection (Fell, 2007). Additionally, state, regional and local governments are increasingly adopting the TBL and analogous sustainability assessment frameworks as decision-making and performance-monitoring tools (Slaper and Hall, 2011). The TBL is adopted for the rural communities in Australia, measuring performance on improved community wellbeing, reduced environmental impact and increased economic vitality (Rogers and Ryan, 2001). Hollos et al. (2011) pointed out that knowledge about the effects of sustainable supplier co-operation on firm performance was limited, so they tested antecedents and implications of sustainable supplier co-operation based on the TBL. Assaf et al. (2012) found that reporting on environmental issues has a slightly higher effect on performance than reporting on social and economic issues based on the TBL framework by a case study in hotel industry. Govindan et al. (2013) presented an effective evaluation model based on the TBL concept for supplier selection in supply chain operations. Nikolaou et al. (2013) proposed a social responsibility evaluation framework based on the TBL framework for reverse logistics systems, by introducing corporate social responsibility and sustainability issues in logistics systems. Sarkis and Dhavale (2015) took the TBL approach to evaluate and select sustainable suppliers by using a Bayesian framework. Winkler et al.