Int. J. Production Economics ∎ (∎∎∎∎) ∎∎∎–∎∎∎

Contents lists available at ScienceDirect

Int. J. Production Economics

journal homepage: www.elsevier.com/locate/ijpe

Effects of carbon tariffs trading policy on duopoly market entry decisions and price competition: Insights from textile firms of developing countries

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ARTICLE INFO

Article history:
Received 27 March 2015
Accepted 27 July 2015

Keywords:
International trade
Game theoretic analysis
Sustainability
Carbon tariffs
Price competition model
Game theory

ABSTRACT

Some developed countries are considering to implement a controversial climate policy called the carbon tariffs policy on the developing-country firms which produce in their own countries and transport goods, such as textiles, to the developed-country markets. This policy has significant impacts on international trade and business. To examine this policy, we consider the scenario in which a developing-country firm and a developed-country firm both manufacture the same type of textile products (which are differentiated but partially substituted). Thus, the cost differences between these two firms establish a price competition model. This model is solved through a two-stage game, where each firm chooses its emissions reduction technology in the first stage and decides its price in the second stage. We explore the effects of carbon tariffs on developing-country firms and offer coping strategies for them. Furthermore, the effects of carbon tariffs on total carbon emissions and global social welfare are also analyzed. We conclude that: (i) carbon tariffs greatly threaten the survival of developing-country firms in the developed-country market; (ii) both total carbon emissions and global social welfare are reduced in the presence of carbon tariffs; (iii) the textile firms of developing countries should make efforts to (1) choose the appropriate technology for emissions reduction, (2) reduce their cost of emissions reduction and (3) reduce the product differences with those developed-country firms.

1. Introduction

In 2012, the average hourly labor cost of the Chinese textile industry is roughly 9% of the counterparts in the U.S. and the European countries (U.S. Bureau of Labor Statistics, 2013). Currently, textile firms in the developing countries take good advantage of their cheap labor and zero cost of emissions to successfully survive in developed-country markets. Textiles have become one of the most competitive exports of developing countries, such as China and Brazil. In 2013, the export percentage of textile is 14% in China, which is the third largest exports (National Bureau of Statistics of China, 2014). According to the US Department of Commerce, textile industry accounts for 4.1% of Brazil's GDP. And Brazil becomes the seventh largest export country of textile products, including yarn, fabric and knits, which follows China, India, US, Mexico, Turkey and Korea. However, this important competitive advantage may not last long because some developed countries are considering to set a bilateral climate policy, called the carbon tariffs, instead of the current unilateral one.

Regarding this climate policy, however, there exist many controversies about the legality and anti-competitiveness of carbon tariffs (Ismer and Neuhoff, 2007; Veel, 2009; Winchester et al., 2011; Moser, 2011). Veel (2009) concludes that "carbon tariffs are, subject to a number of constraints, generally permissible under WTO law. However, it also argues that while carbon tariffs may generally be legally permissible, additional domestic political constraints may significantly limit the set of legal carbon tariffs which are practically feasible in any given state." Despite all these, many developed countries seem to be interestingly in favor of this policy. The U.S. Clean Energy and Security Act (ACES, also known as the Waxman-Markey bill) (H.R. 2454, 2009) was approved by the House of Representatives on June 26, 2009, which authorized the U.S. government to impose carbon tariffs on the imports from some countries, including China. Fortunately, in July 2010, it was reported that the Senate would not consider ACES legislation

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http://dx.doi.org/10.1016/j.ijpe.2015.07.025
0925-5273/

before the end of the legislative term (Hulse and Herszenhorn, 2010). Another fact is that EU had passed the law of incorporation international aviation into EU ETS in 2008, which would take effect on January 1, 2012. Nonetheless, in March 2014, the Council of the EU and European Parliament limit the aviation coverage of EU ETS to emissions from flights within the European Economic Area (EEA) for the period from 2013 to 2016 (European Commission, 2014).

Global textile consumption is estimated to be more than 30 million tonne (t) a year, which yields serious social and environmental impacts within supply chain systems (Chen and Burns, 2006; Shen, 2014). Under the carbon tariffs policy, developing-country firms[1], such as the Chinese and Indian firms, will be subject to large carbon tariffs when their goods enter into the regulated regions of the developed countries. When it comes to textile industry, US is the largest import country of Chinese textile during these years according to China's Ministry of Commerce. For example, CO_2 embodied in Chinese textile flowing to the US are roughly 810 t, which is the fourth-largest among the export to the US in 2006 (Weber et al., 2008; Xu et al., 2009). If the US had levied carbon tariffs by $30/t that year, Chinese textile firms would have paid an extra $24,300 for the CO_2. Considering all the other Greenhouse Gases (GHGs), the Chinese textile firms would have to pay a huge amount of money under the carbon tariffs policy.

Therefore, it is extremely significant for developing-country firms of the textile industry to explore two questions: (i) how the carbon tariffs policy will impact them, and (ii) how they should respond. In this paper, we address these issues by exploring a theoretical two-stage game from the perspective of the developing-country firm. Developing-country firms have access to cheaper labors and resources than developed-country firms do (Banister and Cook, 2011), which leads to heterogeneous goods from these two types of firms in terms of price, carbon emissions and product quality. Thus, there exists a price-emissions competition between a developing-country firm and a developed-country firm. Notice that the textile industry in the developing countries is labor intensive and highly competitive. Owing to the huge export volume of the textile industry in developing countries and the huge emissions of this industry, once the textile industry is levied by carbon tariffs, the developing countries textile firms would suffer a lot. Therefore, the carbon tariffs policy is critical to the textile firms' survival in the developing countries. Thus, the analysis generated by this paper has important implications to the developing countries textile firms.

The rest of this paper is organized as follows: Section 2 presents a concise literature review. Section 3 builds the analytical model. Sections 4 and 5 present the analysis for the cases with and without carbon tariffs, respectively. Section 6 explores the global social welfare issue. Section 7 discusses numerical analysis. Section 8 concludes this paper with a discussion of managerial insights. To enhance presentation, the following notation and symbols are defined in the Appendix: $\overline{a}_{f1}$, $\overline{a}_{l1}$, $\overline{t}^0_{f1}$, $\overline{t}^1_{f1}$, $\overline{t}^2_{f1}$, $\overline{t}^1_{l1}$, $\overline{t}^2_{l1}$, $a_0(t)$, $\varepsilon_0(t)$, $\overline{a}_{01}(t)$, $\overline{\varepsilon}_{01}(t)$, $\overline{\varepsilon}_{02}(t)$, $\overline{a}_1(t)$, $\overline{a}_2(t)$, $\overline{\varepsilon}_1(t)$ and $\overline{\varepsilon}_2(t)$.

2. Literature review

Our research is closely related to the literature of carbon tariffs, technology choices and price competition, which are discussed concisely in the following.

Within the literature of carbon tariffs, many researchers study the effects of carbon tariffs from the perspective of developed-country firms. For example, Böhringer et al. (2014) investigate whether or not carbon tariffs could substantially extend the reach of OECD climate policies by simulating the effects of embodied carbon tariffs with a computable (data-driven) general equilibrium (CGE) model of global trade and energy consumption. Hübler (2012) examines the effects of imposing carbon tariffs under a contraction and convergence climate regime with emissions trading on welfare and emissions in a stylized CGE model. These studies, however, do not analytically examine the effect of carbon tariffs from the perspective of developing-country firms.

Some recent studies discuss effects of carbon tariffs from the angle of developing-country firms. For instance, based on the analysis of China's industrial products export, Shen and Li (2010) employ a dynamic CGE model to study the influence of carbon tariffs on China's industrial production, exports and employment. Li and Mu (2010) analyze the effects of Chinese Government Environmental Regulations on enterprise technological innovation under the pressure of carbon tariffs. They test these effects through constructing an R&D input–output function with the panel data of 36 industries from 2000 to 2008. Using the Zhejiang Energy-Economic input–output model, Pang and Ma (2011) integrate the relevant data from the "Statistical Yearbook of Zhejiang Province in 2007–2009" and the "Zhejiang Energy Balance Sheet" to estimate the impacts of carbon tariffs on trade. But these studies neither consider the price competition of heterogeneous products which is the basis of our work, nor explore the effect of carbon tariffs on global social welfare. Other related studies include Zabaniotou and Andreou (2010), Hitchcock (2012), Plambeck (2012), Choi (2013), Xue et al. (2013), Zhu and Geng (2013), Dong et al. (2014), Wang et al. (2015).

In the literature of technology choice related to carbon emissions, researchers consider the effects of technology choices on emissions (see Zhao, 2003; Krysiak, 2008; Krass et al., 2013; Craig et al., 2012; Drake et al., 2012; Govindan et al., in press). To be specific, Krass et al. (2013) model a Stackelberg game in which a regulator sets a carbon tax rate and a firm selects its production technology and price. Drake et al. (2012) treat the problem in a competitive setting wherein each firm selects a single technology. Both Zhao (2003) and Krysiak (2008) consider a case in which each firm selects a single technology from a continuum of infinite options rather than selecting a portfolio of technologies from a set of discrete choices. Craig et al. (2012) develop a duopoly vertical differentiation model for product carbon labels and treat the technology choice as a continuous one. However, Zhao (2003), Krysiak (2008) and Craig et al. (2012) neither consider the impacts of carbon tariffs on developing-country firms nor offer strategies for these firms to react to carbon tariffs, both of which are our primary interests in this paper.

Price competition has been widely used to study operations under various competitive environments within the general operations management and economics literature. Price competition has been mainly used to study consumers' concerns about product price and quality, such as Moorthy (1988) and Gabszewiczm and Thisse (1979). Conrad (2005) uses the spatial duopoly model to determine how environmental concerns affect price, product characteristics and product quantity among competing firms. Caro and Martínez-de-Albéniz (2012) provide an analytical model based on utility theory that relates customer consumption to price and satiation. Kumar et al. (2012) analyze the duopoly price competition between two network service providers in the presence of four types of users. In Lotfi and Sarkar (2012), each seller seeks to select a price that will be attractive to the buyer and also fetch adequate profits. Li et al. (2012) investigate a two-stage game in which the two service providers first simultaneously select service rates and then simultaneously charge prices. However, none of these studies consider

[1] In this paper, a developing-country firm represents a firm in the developing country which is an unregulated region, whereas a developed-country firm denotes a firm operating in the developed country which belongs to the regulated region.

Please cite this article as: Wang, M., et al., Effects of carbon tariffs trading policy on duopoly market entry decisions and price competition: Insights from.... International Journal of Production Economics (2015), http://dx.doi.org/10.1016/j.ijpe.2015.07.025