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Emission control under private port operator duopoly

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ABSTRACT

Recent trends in regulating maritime vessel emissions have negative effects on the competitiveness of many ports as regulations increase costs for shipping operators calling the ports. This paper develops analytical models to examine the emission standards set by governments for ports in their jurisdictions. Given the emission standards set by governments, which affects fuel cost experienced by shipping operators, ports determine charges for shipping operators. Unilateral, bilateral, and single-country regulation cases are investigated. Specifically, our analysis focuses on how increase in the maximum reservation price of shipping operators, port capacity, and environmental damage costs of ports affect optimal emission standards.

1. Introduction

Ports are strategic nodes that facilitate intermodal freight transportation, provide value-added services, and create jobs. With developments in global trade and maritime infrastructure, port competition has become increasingly intense, especially between ports with common/overlapping catchment areas. Port competition has been further fueled by grand-scale shipping operator alliances, vessel size increases, and advancements in intermodal shipping networks (Song, 2002, 2003; Cullinane et al., 2005; Yap and Lam, 2006; Chang et al., 2008; Bae et al., 2013). Ship emissions in and around ports have also attracted increasing attention. Such emissions, including SOx, NOx, and particulate matter (PM), lead to detrimental health effects for people in surrounding areas. PM emissions from ships, for example, is estimated to account for 60,000 cardiopulmonary and lung cancer deaths each year globally (Corbett et al., 2007).

To mitigate the negative environmental impacts, many ports have implemented emission controls. These emission control measures may result from local laws and national regulations such as in Singapore and China. At the local level, port-city municipalities pass legislation to regulate ship emissions at and around ports such as in Antwerp and Rotterdam (Lam and Notteboom, 2014), or establish city-wide air pollution mitigation plans with inclusion of the port sector as in Shanghai and New York (Zheng et al., 2017; Lee et al., 2014). Port authorities, which typically assume public roles, have also been independently adopting emission control measures (Tichavska and Tovar, 2015; Winnes et al., 2015).

While generating environmental benefits, port emission control measures increase costs for shipping operators. Note that the term “port emission” in this paper refers to ship emissions at and around ports. Oceangoing shipping costs can increase by 50–160% in switching from fuel containing 4.5% sulfur (the current standard for non-Emission Control Area (ECA) ports) to fuel containing 0.1% sulfur (Notteboom, 2011). Alternatively, ships may install scrubbers to filter out sulfur content, but this remains expensive (Brynolf et al., 2014). To avoid these additional costs, shipping operators may prefer calling ports with lower or no emission controls, which discourages emission control at ports. A news article concerning the designation of the Pearl River Delta in China as an ECA illustrates

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this point (Wang and Feng, 2014):

"*The fuel cost rise may give a disadvantage to ports within the Pearl River Delta and may also damage the competitiveness of corporations using these ports. Industries may be lured to transfer to places outside the ECA and thus damage the local employment.*"

A thorough understanding of emission control impacts on port competition is thus needed, but is currently lacking. The existing literature has focused on the interplay among port charges, shipping demand, and capacity expansion (Basso and Zhang, 2007; De Borger and Van Dender, 2006). The implications of emission regulations for ports has attracted attention only recently.[1] A notable study by Homsombat et al. (2013) found that if a port levies a higher pollution tax, shipping demand at the port will decrease. The literature, however, has not considered how to determine emission standards and the sensitivity of standards to maximum reservation price, port charges, port capacity, port congestion, and the extent of environmental damage. Neither has the literature investigated the effects of competing ports setting different emission standards. As mentioned prior, this is important for countries and port authorities to consider in regulating ship emissions at and around ports.

This paper develops analytical models to investigate optimal port emission standards in a duopoly port environment. Emission standards regulate the quality of fuel used by shipping operators, in which improved fuel quality (i.e., less noxious gases emitted from fuel consumption) increases fuel cost. While shipping operators can comply with emission regulations through other policy options such as installing scrubbers or using liquefied natural gas (Cullinane and Bergqvist, 2014), we focus on fuel switching in this paper. This is due to the fuel switching option is readily available and the most widely adopted measure by shipping operators.

We consider cases in which ports are located in both the same country and different countries. National governments set emission standards for ports in order to maximize social welfare. Given the emission standards, profit-maximizing private port operators set port charges. However, it should be noted that although we consider national governments being responsible for setting emission standards, the modeling framework is readily applicable to cases in which emission standard setting is established by municipalities or port authorities. Thus, the insights obtained should be interpreted as more generic than specific to the context of national governments setting emission standards.

Utilizing the analytical models, we seek to answer the following questions:

(a) How will national governments require shipping operators to internalize environmental damage by setting port emission standards when port operators seek maximizing profits?
(b) How will the maximum reservation price of shipping operators, port capacity, and environmental damage costs affect optimal port emission standards?
(c) How will different emission control cases affect establishing emission standards and interaction between port operators? Specifically, three cases are investigated: (1) unilateral regulation in which only one country actively regulates port emissions; (2) bilateral regulation in which two port operators in two countries compete subject to emission standards set by their respective national governments; (3) a single country in which two ports are located.

In answering the questions above, this paper makes three major contributions to the literature. First, unlike existing research concerning port competition (e.g., De Borger and Van Dender, 2006; De Borger et al., 2008; Luo et al., 2012; Chen and Liu, 2016), we consider port emission standards as decisions made by national governments. Emission standards affect the quality of fuel used, and consequently, shipping cost. Second, we examine the effects of port capacity on optimal emission standards. Port capacity is a major determinant in port selection of shipping operators (Chang et al., 2008). Yet it remains unknown how port capacity increase may change optimal emission standards of the port and rivals.[2] In fact, capacity consideration is also lacking in non-maritime emission control research (e.g., Barrett, 1994; Burguet and Sempere, 2003; Greaker and Rosendahl, 2008). Third, we investigate both symmetric and asymmetric cases, the latter featuring conditions in which not all ports are subject to emission controls (see Section 4.3).

Furthermore, we consider landlord ports in which private port operators manage terminals and labor allocation. The role of a port authority is limited to providing basic infrastructure and mandatory services such as security. Worldwide, the port sector has witnessed a growing involvement of private operators as a means of improving administration efficiency and attracting additional capital (Cullinane and Song, 2002). Given that the primary focus of a private port operator is maximizing profit (De Monie, 1996), the consideration of private port operators will promote understanding of public-private interaction in the context of port emission controls; more specifically, how governments should internalize environmental damage by setting emission standards.

The remainder of this paper is organized as follows: Section 2 reviews the existing literature regarding port competition and emission regulations. Section 3 develops the theoretical models of emission regulation for symmetric private port operators and governments. Section 4 examines the case of asymmetric port operators and governments under three emission regulation cases. Numerical analysis is described in Section 4. Conclusions and directions for future research are offered in Section 5.

[1] Throughout this paper, we use "emission control" and "emission regulation" interchangeably.

[2] Empirical evidence points to the growing port capacities in the world. For instance, "based on the estimated capacity developments up to 2030, it seems there would already be sufficient capacity planned in most of the regions to accommodate the future traffic growth. Several regions [e.g., Southeast Asia and China] seem to have quite severe over-planning of capacity increases" (Mooney, 2016). Given this trend, analyzing the effect of capacity expansion on emission standard seems to be timely.