



Prisoner's dilemma on competing retailers' investment in green supply chain management

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ABSTRACT

Nowadays, along with increased public environmental awareness and widespread upstream investments in green production, some retailers have begun to invest in the packaging and distribution processes to shape their public images and enhance their competitiveness. However, under the pressure of competition and existing upstream investments, retailers' incentives to invest may be weakened. In this paper, we study whether and when competing retailers should invest and explore the performance of the equilibrium outcome. First, we find that a retailer prefers to invest only with a high efficiency, which can endow her with a considerable demand improvement at an acceptable cost level. Second, we demonstrate that a retailer counterintuitively will not always benefit from her rival's investment inefficiency because the manufacturer in this case will reduce his investment level, which cannot sufficiently expand the product market size. Third, we verify the existence of a prisoner's dilemma for retailers under a medium investment efficiency because although green investment enhances demand, it also increases the unit cost and subsequently the retail price. Additionally, a retailer facing competition is especially unwilling to improve her price compared with her rival. Fourth, we present an interesting insight that the prisoner's dilemma area will be decreased with a sufficient upstream investment efficiency since a retailer will focus less on the downstream competition for market occupation but more on the upstream investment that can expand the total market size. The decreased hostility alleviates the prisoner's dilemma.

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1. Introduction

Over the past few decades, environmental protection (including sustainable development, the low-carbon economy and green GDP) has attracted broad attention. Spurred by increasing public environmental awareness, many manufacturers have already actively engaged in green investments, such as designing environmentally friendly products in the research and development process. Nevertheless, in recent years, green investment in the design and production processes alone has become inadequate. With the growing popularity of online retail, the inefficiency and waste in the product packaging and distribution processes have aroused wide concern. As reported by the State Postal Bureau of China, the Chinese express market in 2015 had increased to 20.6 billion. This

market used 9.9 billion carton boxes, 8.26 billion plastic bags, 16.95 billion miles of packaging tape in 2015 (Techsina, 2016). China's vice environment minister Zhao indicated that in addition to manufacturing processes, a tremendous waste of resources and energy also exists in the consumption and distribution processes; therefore, it is particularly urgent and significant to promote green retail and green logistics (Aifan, 2017).

Along with this increasingly urgent social need, some downstream retailers have recently begun to introduce green investment in the packaging and distribution processes. In August 2013, COFCO I buy nets claimed to replace carton boxes with environmentally friendly test boxes and plastic bubble chamber packaging with reusable chamber packaging (Zhang and Li, 2013). Later, in March 2017, JD.COM developed its distribution system and established a logistics packaging laboratory aimed at promoting the use of cleaner alternatives, such as environmentally friendly, biodegradable packaging (Aifan, 2017). Through these green investments, retailers can shape their public images and improve both their reputations and their appeal to consumers.

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Despite these visible benefits, green investment in the packaging and distribution processes is still difficult to promote, particularly under the pressure of intensified price competition. Considering the inevitable increased cost resulting from going green, retailers are reluctant to make green investments that will lead to a higher price compared with that of their rivals and thus decrease their competitiveness for price-sensitive customers. Given this fear, individual enterprises in different areas and industries do not dare take a step to invest without careful consideration. In addition to interacting with competition, the downstream retailers' decisions on green investment also interacts with the existing upstream green investment in production. Efficient retailers may encourage the manufacturer increase output. In turn, the different degrees of green production also affect retailers' attitudes toward investment.

Based on these considerations, such strategic interactions by competing retailers with respect to green investment in the presence of upstream investments give rise to interesting questions that are worthy of exploration. First, given these interactive impacts, will competing retailers choose to make green investments? Which factors affect the strategy decisions of retailers and how? Second, in addition to the effects of external factors, how will two retailers interact with one another? Will a retailer always benefit from her rival's investment inefficiency? Third, after combining two retailers' preferences, is the equilibrium outcome with respect to downstream investment in the best interests of the two completely "rational" retailers? Further, will the downstream equilibrium align with the upstream manufacturer's preference? Fourth, if these inconsistencies exist, what affects them, and which methods can be taken to remedy them?

To capture the aforementioned issues, we develop a model in which two differentiated retailers procure products from a manufacturer and then sell to the market. To attract environmentally conscious consumers, the upstream manufacturer usually determines an appropriate degree of green investment in the research and development process to expand the product market. And then, two downstream retailers can also choose to invest additionally in the packaging and distribution processes to enhance their competitiveness. Based on this framework, we study three cases to explore the two retailers' preferences for green investment: (i) neither retailer makes green investment, (ii) one retailer makes a green investment while the other retailer does not make a green investment, and (iii) both retailers make green investments. After deriving the equilibrium solutions for these cases, we obtain some novel insights into the downstream equilibrium with respect to green investments.

First, we find that a retailer will prefer to make a green investment only with a sufficiently high efficiency, which can endow her with a considerable demand improvement at an acceptable cost level. Meanwhile, despite the competition, a retailer's preference will not change with her rival's investment strategy. Further, we demonstrate that the retailers will be more reluctant to invest when the manufacturer's investment efficiency is decreased. This finding is because an inefficient upstream manufacturer cannot expand the product market sufficiently, which increases the downstream competition for market occupation and then lowers the retailers' willingness to perform costly investments.

Second, through analyzing trends in retailers' decisions, we find that a retailer counterintuitively will not always benefit from her rival's investment inefficiency. Indeed, under competition, a retailer can be endowed with a price advantage when her rival is inefficient and has to pay a larger cost. Nevertheless, this is not the only effect here. In this scenario, when confronting the downstream inefficiency, the upstream manufacturer will reduce his wholesale price and his investment degree to maintain the level of output. However, the lower upstream investment will decrease the market

size for both retailers and then exert a negative indirect effect on both of their performances. When the upstream efficiency is sufficiently high or the competition is intensified, a retailer will suffer from her rival's inefficiency.

Third, we verify the existence of a prisoner's dilemma for retailers under a moderate investment efficiency. This dilemma occurs because although green investment enhances demand, the unit cost and consequently the retail price increase as a result; additionally, a retailer under competition is especially unwilling to improve her price compared with her rival. Further, with respect to the manufacturer, we find that it also prefers downstream investment only with a sufficient downstream efficiency since the retailers' inefficiencies will improve the retail price and consequently decrease production output. Comparing the upstream preference and downstream equilibrium, we find that an inconsistency between upstream and downstream preferences will also arise under a medium downstream efficiency; specifically, the manufacturer prefers investing, while the retailers prefer not to invest. This result indicates that competition will reduce the downstream green investment level, causing poor performance throughout the whole supply chain. In this case, the appropriate government regulation or industry alliance is particularly necessary to benefit all the participants.

Fourth, we present an interesting insight that both the prisoner's dilemma area between downstream retailers and the inconsistency between upstream and downstream will be decreased by the degree of the manufacturer's investment efficiency. From the perspective of the manufacturer, a sufficient efficiency will directly increase his degree of investment and then expand the product market size further; this expansion can decrease the downstream competition and alleviate the inconsistencies. From the perspective of the retailers, a retailer will also focus less on the downstream competition for market occupation but will focus more on the upstream investment that can expand the total market size. The retailers will work together to induce a larger upstream investment and thus be less hostile to each other. Following this, the prisoner's dilemma decreases. This result indicates that in addition to direct regulation, the appropriate subsidy on improving manufacturer's investment efficiency can also alleviate the prisoner's dilemma. Allowance on the upstream manufacturer can improve not only its own performance but also that of the whole supply chain.

The remainder of this paper is organized as follows. In Section 2, we briefly review the related literature. In Section 3, we set up the model. In Section 4, we separately analyze the optimal decisions of the manufacturer and retailers in cases NN, IN and II. In Section 5, we explore the equilibrium outcome with respect to the retailers' investment strategies and verifies the existence of the prisoner's dilemma. In Section 6, we further investigate the manufacturer's preference. In Section 7, we conclude the paper with a brief discussion.

2. Literature review

Our research lies at the intersection of the literature on green investment and that on dual-channel supply chains. Moreover, in the area of green investment, our work is further related to existing upstream investment and downstream investment. Next, we describe how our work relates to the literature in these areas.

With the marked improvement in consumer environmental awareness in recent years, green investment has attracted considerable theoretical and empirical attention. To reduce environment pollution and avoid unnecessary energy waste, in 1989, the Chinese government established green standards for equipment that mandated the maximum allowable energy consumption for 30 types products (Price et al., 2011; Rock, 2012). Further, the US "eco-labeling" program (Mason, 2006; Waechter et al., 2015) and the Chinese "China Energy Label" (Zhan et al., 2011) were introduced to

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