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# Pricing and quality decisions and financial incentives for sustainable product design with recycled material content under price leadership

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ABSTRACT

Design for recycling has been promoted by companies and governments around the world as one of the most important practices for achieving sustainability. The success or failure of such a practice, however, depends heavily on the financial incentives for firms to design products with more recycled or recyclable material contents. An interesting phenomenon that can be observed in many markets with products made predominately from either virgin or recycled materials is the existence of price leadership. In this paper, we utilize an interdisciplinary approach with both theoretical and empirical analyses to study the pricing and design decisions for products with virgin and recycled material contents in a duopoly market consisting of both the environmentally conscious (green) and non-environmentally conscious (brown) consumers under price leadership. Our analytical results show that the brown segment's efficient quality provides an "anchor product position" for the price leader regardless of whether the price leader is a brown or green firm. The price follower's financial incentive for becoming a green or brown firm will then lead to different cases of price leadership with very different environmental consequences. Specifically, the arrangement where the brown and green firms are the price leader and follower, respectively, leads to more environmentally friendly design decisions than those under the other arrangement where the duopolists switch their pricing roles. In addition, we conduct an empirical analysis to explore the specific types of price leadership in the markets of aluminum, cardboards, and PET. Based on the equilibrium pricing and quality decisions, we analyze the financial incentives for the more environmentally friendly case of price leadership to be realized, and derive important insights to formulating strategies and policies to implement the practice of design for recycling from the interdisciplinary perspective.



## 1. Introduction

Design for recycling, which aims to increase a product's recycled/recyclable material content, has been promoted by companies and governments around the world as one of the most important practices for achieving sustainability. One well known recent example is the Waste Electrical and Electronic Equipment (WEEE) Directive which has gone into effect since 2006 in most EU member states (with at least framework regulations in most countries). The law requires the "producer-polluter" to take the responsibility of recycling electronic equipment when it reaches end-of-life as a policy to induce the producer to implement the practice of design for recycling (Financial Times, 2006a; Lauridsen and Jørgensen, 2010). The success or failure of such a practice, however, depends heavily on the financial incentives for firms to design products with more recycled or recyclable material contents. According to Malcolm Wicks, the UK Minister for Energy, WEEE's cost to UK electrical goods makers could be up to £500 million per year, although that amount would be offset if recycled materials could be reused in product design to give the industry higher financial incentives with improved profitability (Financial Times, 2006b). Similar initiatives/legislations have been under consideration in several other countries around the world, including United States and China (see, e.g., U.S. Office of Federal Environmental Executives, 2004; China Daily, 2004).

Despite the economic and regulatory pressures, today's firms still have very different responses to the call for the implementation of design for recycling. Some firms have actively involved in designing products with high recycled material content. For example, because of the recent environmental protection drive in China, many traditional pulp mills were closed. As a result, 50% of the industry's fiber now comes from recovered paper. In addition, 90% of China's packaging board and newsprint capacity

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is recovered paper-based (Leach, 2005). Many other firms, however, still adopt a conservative, wait-and-see policy (Financial Times, 2006b). The fact is that, to implement the practice of design for recycling, companies need to deal with several operational, marketing, and financial challenges. On the operational side, the limited grade (quality) of secondary (recycled) materials due to impurities has long been a problem that limits their usability in new products, and very often utility of materials has to be maintained through the addition of high primary (virgin) materials (see, e.g., Harvard Business Review, 1993; Malloy, 1996; Ferriolo and Miller, 2001; Verhoef et al., 2004). One example is about the early competition in the U.S. steel industry between the integrated firms, which produced outputs predominantly from virgin materials, and minimills, which operated mainly on scrap steel. The low quality of the products manufactured from the electric arc technology of minimills in the early years was one of the main reasons for the integrated steelmakers to ignore the opportunity of steel recycling (Adams, 1977; Christensen, 1997).

On the marketing side, consumer acceptance is a key factor to the success of design for recycling as experience of product recycling in the past twenty years has shown that *nothing is truly recyclable if there is no market for the recyclate* (Bacot et al., 2002). While some consumers seem to have adopted a positive attitude towards green/environmental marketing, it is still not clear whether they will actually incorporate environmental information into their purchasing decisions (Pedersen and Neergaard, 2006). Despite the fact that some consumers do value a product's environmental attributes (see, e.g., Laroche et al., 2001; Camacho-Chena et al., 2004), such as recyclability and low carbon footprint, many others pay no attention or only lip service to environmental purchasing. According to a survey done by RoperASW (Ginsberg and Bloom, 2004), despite the growing interest in environmental issues, 52% of American consumers are still uninvolved or very disinterested in green purchasing. Such a difference also exists among industry buyers from the so-called green and non-green firms in terms of whether environmental considerations are incorporated into the procurement and supply-chain decisions (New et al., 2002).

One interesting phenomenon that can be observed in many markets with products made predominately from either virgin or recycled materials is the existence of price leadership (or the lead–lag relationship of price movements). For example, Figs. 1–3 show the monthly average price data, published by the Sound Resource Management (2007), in the markets of three commonly seen products which can be made from recycled or virgin materials: (i) PET (made from recycled PET bottles or PET pellets), (ii) aluminum (made from recycled aluminum cans or aluminum ingot), and (iii) cardboard (made from recycled cardboard boxes or softwood kraft pulp) in the United States. According to the empirical tests to be presented in Section 6, the lead–lag relationship of price movements, as an indicator of price leadership, can be observed in all the three markets. Specifically, in the market of aluminum, the price of recycled material-based product (recycled aluminum) follows that of virgin material-based product (aluminum ingot). In the markets of PET and cardboards, however, the prices of recycled material-based products (recycled PET and

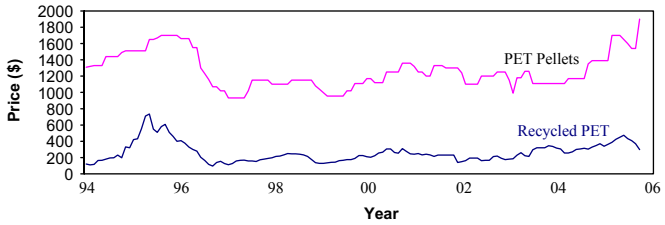


**Fig. 1.** Prices of recycled PET & PET pellets ($/ton).

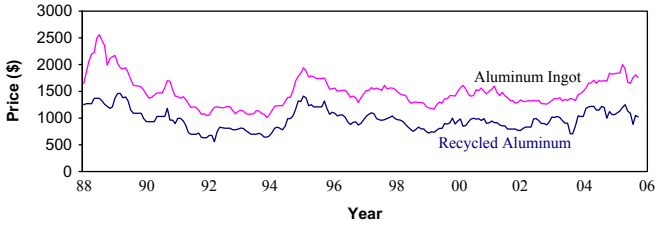


**Fig. 2.** Prices of recycled aluminum and aluminum ingot ($/ton).

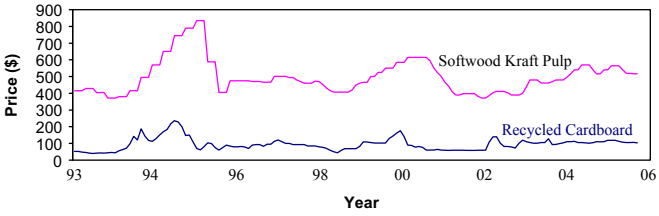


**Fig. 3.** Prices of recycled cardboard and softwood kraft pulp ($/ton).

cardboards) lead those of virgin material-based products (PET pellets and cardboards made predominately from softwood draft pulp). As another example, some integrated steel firms were considered as the price leaders in the regional markets in the steel industry in the 1970s (Adams, 1977). It can also be empirically shown that the average price of integrated steel firms led that of minimills from 1981 to 1992 based on the data published in New Steel (1994).

In this paper, we utilize an interdisciplinary approach with both theoretical and empirical analyses to study the pricing and design decisions and financial incentives for sustainable product design with virgin and recycled material contents. We consider a duopoly market which consists of both the environmentally conscious (green) and non-environmentally conscious (brown) consumers under price leadership to analyze the pricing decisions in the short term and the quality (positioning) decisions in the relatively long term. We also investigate the environmental consequences and financial incentives under both exogenous and endogenous price leadership arrangements to derive useful managerial and policy insights into the implementation of the practice of design for recycling. Empirical tests are also conducted to explore the specific types of price leadership in the markets of PET, aluminum, and cardboards. This paper is interdisciplinary in nature because it integrates the concepts and theories of a number of functional fields, including operations, marketing, finance, design engineering, and environmental management. The analytical approach used in the paper is also interdisciplinary because we utilize different research methodologies such as product design and pricing models, game theory, and empirical tests, to study the financial incentives for sustainable product design with recycled material content under price leadership.

The remainder of the paper is organized as follows. In Section 2, we review related literature. In Section 3, we describe the basic model structure. In Section 4, we analyze the pricing and design decisions of firms under different types of price leadership. In Section 5, we investigate the financial incentives for sustainable product design under price leadership. In Section 6, we test different types of price leadership in three selected markets. Concluding remarks are given in Section 7.

## 2. Related literature

Interdisciplinary research is based on active interaction which takes place not only in the framing of research problems across