DESIGN CHOICES AND ENVIRONMENTAL POLICIES

CIRANO note based on an article written by *Sophie Bernard*, April 2016

Product environmental quality and green design have been largely explored in the literature. The novelty about the author's approach is that she formally considers the multidimensionality of product design as well as the potential for complementarity or competition in the selection of product attributes.

During a product life cycle, pollution is generated at all stages: during material extraction, production, consumption, and end-of-life treatment and disposal. However, many of these environmental impacts actually result from decisions taken during the product development stage. Design choices influence material choices, production technologies, energy performance during use, recyclability, durability, and so on. These are referred to as design *dimensions*.

The paper focuses on the types of cross relationships between design dimensions. For example, new composite materials in aircraft design reduce aircraft weight and gas consumption. However, these materials are almost completely nonrecyclable. The result is an environmental trade-off between energy consumption during use and end-of-life treatment, which makes for a competitive scenario. Conversely, if a given technology simultaneously improves product durability and recyclability, these dimensions would be considered complementary.

There is a large variety of impact categories (e.g., global warming, water pollution, resource depletion), yet policies generally target specific pollutants, specific sectors or specific life cycle stages in isolation. Consequently, pollution externalities may be subject to different tax rates, either because the nature of pollutants emitted during production and consumption differs (e.g., CO2 emissions, toxic waste), or because a single pollutant is taxed differently in different sectors or life cycle stages. Firms may therefore select design attributes that come with uneven political incentives for reducing their environmental impacts.

In the theoretical model proposed by the author, a firm interacts with consumers and a regulator. Before the production stage, the firm must choose the levels of three design dimensions: 1) energy performance during production, 2) energy performance during use, and 3) durability. The two first dimensions are inversly linked to pollution emissions. Durability does not generate externalities, but determines the frequency of emissions during production. Depending on the assumptions, the dimensions are said to be complementary, neutral, or competitive. The regulator can apply targeted environmental taxes on emissions during production or consumption.

The main results of the study shed light on the consequences of modifying public policies. When all design dimensions are complementary or neutral, tax increases always spur greener design and reduce emissions. However, when some design dimensions are competitive, a targeted emission tax can result in environmental burden shifting, with an overall increase in pollution. Another result shows how a tax on emission during production can precisely discourage investment in environmental quality during production.

The social optimal taxation level implies a uniform tax on emissions during both production and consumption. The study also explores second-best policies. As long as pollution externalities are internalized, the government can ignore the possibility for firms to adjust the level of durability. However, when some policy instruments are inappropriate, the choice of durability matters. Under given circumstances, the government will want to regulate and constraint durability.

In general, any deviation from the optimal tax levels can impact all three dimensions. Second-best policies must take into account crossed effects.

The author concludes that targeted environmental policies should take into account firms' responses in terms of product design, especially when design dimensions show competitive cross relationships.

The full study is available on CIRANO's Website at:
http://cirano.qc.ca/files/publications/2016s-09.pdf