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Analysis

Predicting consumer demand responses to carbon labels☆

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ABSTRACT

Providing carbon footprint labels for all food products is a daunting and potentially infeasible project. Knowing how consumers substitute away from high carbon goods and what they choose as substitutes is essential for understanding which goods are likely to result in meaningful reductions in carbon emissions. This paper proposes a model to systematically estimate how consumers will respond to information from a carbon footprint label. Our model uses consumers' value of their individual carbon footprint with own- and cross-price elasticities of demand data on carbon emissions from life cycle analysis to simulate shifts in consumer demand for 42 food products and a non-food composite, and subsequent changes in carbon emissions from different labeling schemes. Our simulation results have several findings, including: (1) carbon labels can reduce emissions, but labeling only some items could lead to perverse impacts where consumers substitute away from labeled goods to unlabeled goods with a higher carbon footprint; (2) carbon labels can inform consumers such that their previous beliefs about carbon footprints matter; and (3) carbon labels on alcohol and meat would achieve the largest decreases in carbon emissions among the 42 food products studied.

Consumers are increasingly making civic and environmental statements through the products they purchase, especially food (Onozaka et al., 2010; Grebitus et al., 2013). Carbon footprint labels provide information about the global warming impacts of products, and thus may help concerned firms and consumers voluntarily reduce their carbon footprint. Research suggests consumers are more likely to take voluntary pro-environment actions when consumers are well informed about the environmental impact of their actions (Polonsky et al., 2012) and when environmentally friendly actions are easy (Green-Demers et al., 1997). If high carbon goods have low carbon alternatives that are substitutes with the same or lower prices, consumers are more likely to respond to these labels (Vlaeminck et al., 2014; Lanz et al., 2014). In this paper we develop the Environmental Impacts of Changes in Consumer Demand (EI-CCD) model to predict the environmental impact of labeling products by quantifying own- and cross-product substitution possibilities.

The EI-CCD model uses own- and cross-price elasticities of demand, current prices and quantities of consumer products, and the carbon footprint of consumer products as inputs to predict shifts in consumer demand. The EI-CCD model helps policy makers and others interested in maximizing the impact of labels to identify which products would provide the largest decreases in carbon emissions. The EI-CCD model is also a tool that can be used by other researchers to quickly quantify cross-product effects using already available data. We provide an example of how the EI-CCD model can be applied to food, but the model can be used for a much wider array of consumer products. Given the expansion of environmental labeling and information schemes (Gruère, 2015) we believe a model that predicts the environmental effectiveness of labeling schemes, using pre-existing data, will be a useful tool to both policy makers and researchers.

A large literature on life cycle analysis (LCA) has developed techniques to estimate carbon footprints. Economics is a central component of one of the main tools for calculating carbon footprints (Hendrickson et al., 2006), but economics is rarely used to predict whether firms and individuals are willing and able to act on the information that a

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carbon footprint provides. For example, Weber and Matthews (2008) compare the carbon reductions from buying only locally sourced food[1] to a dietary shift from red meat and dairy to chicken, fish, eggs, or vegetables. The authors calculate the carbon impact of various food products but do not apply demand theory. Instead the authors make ad hoc assumptions such as a 24% reduction in expenditures on red meat would result in a 24% increase in expenditures on chicken. Many other academic papers do not fully develop the consumer substitution portion of their analysis (e.g., Carlsson-Kanyama et al., 2003; Garnett, 2008; Bin and Dowlatabadi, 2005; Jones and Kammen, 2011; Mungkung et al., 2012; Vieux et al., 2012), and most of the work on consumer substitution patterns from labels considers only individual products or small groups of products (Lanz et al., 2014; Matsdotter et al., 2014; Vlaeminck et al., 2014; Michaud et al., 2013; Onozaka et al., 2012; Vanclay et al., 2011). This gap has been noted in Edwards-Jones et al. (2009) and is further demonstrated in Table 1, which presents examples of the ad hoc methods that previous work has applied to consumer substitution patterns in food choices. Table 1 suggests how the EI-CCD model could have improved previous studies. Table 1 is not an exhaustive list of the food and climate change literature but an illustration of the types of research that could benefit from the EI-CCD model.

The EI-CCD model can be used to inform policy debates as well as research. Experts outside of academia frequently make statements about how changes in diet can produce changes in greenhouse gas emissions. Behind these statements are ad hoc assumptions about what foods consumers consider to be substitutes (and complements). David Friedberg, the CEO of the Climate Corporation, recently asserted "we are sending millions of tons of protein to China to feed hogs. We should really just skip the hogs and grow the quinoa" (Specter, 2013, pg. 43). However, researchers, policy makers, nutritionists and home cooks may argue that quinoa and pork are not substitutes. To address concerns about using such ad hoc assumptions in measuring the effects of carbon labels on consumer demand and carbon emissions, the EI-CCD model incorporates cross-price elasticities from the demand analysis literature that objectively capture substitute and complementary relationships between products.

The sign and the magnitude of the cross-price elasticity indicate whether two products are substitutes (positive cross-price elasticity), complements (negative cross-price elasticity) or unrelated (a cross-price elasticity of zero). Furthermore, demand theory allows a modeler to predict the size and overall direction of a change in the market of one good on markets for related goods. The EI-CCD model connects this economic information to LCA data on carbon emissions to capture the environmental effects of labels. Hence, the EI-CCD model can be used to calculate the environmental impacts of consumer responses that result from carbon footprint information and find which food products are most likely to produce reductions in carbon emissions. This will help researchers looking to account for the broader impacts of a label as well as policymakers and non-governmental organizations who are focused on reducing carbon emissions through the food supply (e.g., Environmental Working Group, 2011).

Generally, consumers like the idea of carbon labels (Hartikainen et al., 2014) and research has shown that consumers are responsive to carbon labels on coffee, apples, tomatoes, roses, and pet food (Nielsen, 2015, Onozaka et al., 2012; Michaud et al., 2013; Vanclay et al., 2011). However, labels can be most effective when consumers understand their message (Sharp and Wheeler, 2013; Polonsky et al., 2012), and evidence from focus groups suggests that this is not automatically the case (Hornibrook et al., 2013; Gadema and Oglethorpe, 2011; Upham et al., 2011). For example, Spaargaren et al. (2013) found that when labels were simply presented with no additional information element to explain what they mean, there was no significant change in CO_2 emissions. However, when accompanied with additional information, there was a significant 3% decrease in CO_2 emissions. In addition, consumers must also trust and understand how to use labels (Lyon and Montgomery, 2015; Thøgersen, 2000). Finally, a label must provide an opportunity for consumers to switch from goods with a high carbon footprint to those with a low carbon footprint. Whether consumers have green substitutes for brown products will determine whether this final criterion is met.

When Vanclay et al. (2011) labeled food products in a local supermarket, the researchers chose the products to label using the best advice available at the time, which was to pick "big items" that "exhibited high turnover and sufficient customer choice." One of those products was fresh milk. All the milk in this supermarket came from the same processing facility, so differences in the carbon footprints were a function of packaging, especially container size. Larger containers were given a green carbon footprint and smaller containers were given a black carbon footprint based on the per ounce carbon emissions.[2] While consumers were willing to switch between all other types of products that were labeled, consumers did not switch to larger containers of milk despite the environmental message. This finding is not unexpected in that Stockton and Capps (2005) found that the cross-price elasticity of milk container sizes is zero, implying that different package sizes of milk are not substitutes in consumption. Furthermore, Stockton and Capps (2005) estimated cross-price elasticities for other beverages with regard to container size, and found that these products were more substitutable across beverages (e.g., bottled water versus juice) and within container sizes. Hence, based on this economic evidence, it is unlikely that a proposal to label milk according to carbon emissions based on differences in containers would achieve any carbon reductions.

Many public and private initiatives have emerged to provide carbon footprint labels (Gruère, 2015). For example, Tesco supermarkets in the United Kingdom promised a "revolution in green consumption" in 2007 by pledging to carbon label all 70,000 of its products. This pledge was dropped in 2012 as it became apparent that the task was too difficult, with each product requiring "a minimum of several months' work" (Quinn, 2012; Vaughan, 2012). A more feasible plan may be to label a subset of products, using demand parameters and rough carbon footprint estimates to determine which groups of products will yield the highest carbon emission reductions (Shewmake et al., 2015). The EI-CCD model can identify which products would be the best to carbon label and which products may lead to perverse responses from substitution patterns that replace high carbon products (such as beef) with even higher carbon substitutes (lamb).

To our knowledge, this study is the first to apply a rigorous economic model to address the question of how consumers will respond to labels that tell consumers the carbon content footprint (measured in CO_2eq) of multiple goods. Previous studies have examined how consumers will respond to carbon footprint labels on individual items such as apples, roses, beef and subsets of goods[3] through surveys (Onozaka and Thilmany McFadden, 2011; Onozaka et al., 2012; Grebitus et al., 2013) or experiments (Michaud et al., 2013; Vanclay et al., 2011) (see Table 1) and the rebound effect from switching to vegetarian diets (Grabs, 2015), but these studies do not account for changes in the demand for complements and substitutes for the labeled product.

The EI-CCD model provides several intuitive findings that are nonetheless often neglected in the literature. The simulations based on the EI-CCD model suggest that goods with low-carbon substitutes, consumers with inaccurate beliefs about the carbon footprint of the good, and high-carbon goods that have large market shares are most likely to result in relatively large reductions in carbon emissions from carbon

[1] A reduction of approximately 0.36 tons of CO_2eq/household per year.

[2] Per ounce, a small container of milk has a higher environmental impact due to the packaging. Consumer psychologists have suggested that evaluative metrics are more effective in communicating environmental messages to consumers. Vanclay et al. hence used a black/yellow/green label where green was the lowest carbon option and black was the highest carbon option.

[3] Vanclay et al. (2011) examine the markets for milk, spreadable butter, canned tomatoes, bottled water, and non-perishable pet foods.