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RESEARCH ARTICLE

The future of carbon labeling – Factors to consider

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Abstract
Compared to other policy instruments that aim to change consumer behavior, information provision is perhaps the least controversial. An important question is how information in the form of carbon labels can contribute to direct food consumption toward reduced climate impact. From a policy guidance perspective, there is a need to identify how the labeling strategy affects consumers' ability to identify lower emitting food products and the behavioral change due to carbon information. Key aspects of a carbon label are discussed, as well as the implications of different labeling schemes. Drawing on economic and behavioral theories, we propose that, to assist consumers in identifying changes in consumption that contribute to significant reductions in their climate impact, a carbon label must enable comparisons between product groups and not only within narrowly defined product groups. This suggests mandatory labeling, since producers of high-emission products are less likely to display such labels. However, it is important to consider both costs and benefits of labeling schemes and to consider complementing labeling with other policy instruments.

Keywords: carbon label; climate label; consumer behavior; food choice

JEL codes: D11; D82; D83; Q13; Q18

1. Introduction

The food sector is a major contributor to climate change, and particularly, meat and dairy production are heavy emitters of greenhouse gases (Godfray et al., 2018; Poore and Nemecek, 2018). To reduce the climate impact from the food sector in line with food-related sustainability development goals and commitments under the Paris Agreement, changes in consumption patterns are vital (Moran et al., 2020; Willet et al., 2019). Broadly, there are four areas of measures to pursue to attain such changes in consumption patterns: (i) financial measures, such as taxes or subsidies, (ii) regulations of production methods and product reformulation, (iii) choice architecture, where the decision environment is altered to nudge consumers, and (iv) information to assist consumers with increased knowledge and support (Just and Byrne, 2019). An important question is how point of purchase climate information in the form of carbon labels can contribute to direct food consumption toward reduced climate impact.

Insights on the effects from carbon labels on consumer choices are mainly based on survey and experimental studies. Typically, the effects on consumer choices are investigated for one selected product category and one specific carbon label (Onozaka and McFadden, 2011; Grunert et al., 2015; Peschel et al., 2016; Apostolidis and McLeay, 2016; Elofsson et al., 2016; Feucht and Zander, 2017; Lombardi et al., 2017; Akaichi et al., 2020; Canavari and Coderoni, 2020; Wynes et al., 2020; Lohmann et al., 2022), although some studies include wider ranges of products categories (Edenbrandt et al., 2021; Edenbrandt and Lagerkvist, 2021) and compare more than one label (Thøgersen and Nielsen, 2016; Meyerding et al., 2019; Carlsson et al., 2021). Rondoni and Grasso (2021) review the literature on carbon labels on food products and conclude that consumers are not well informed about the climate impact from food and that policy makers should develop a consumer-friendly carbon label. However, it is not well documented how the labeling strategy and characteristics of the label affect consumer behavior. This is a central shortcoming with the current body of research, especially from a policy guidance perspective. Discussions are ongoing in policy making institutions[1], and a number of initiatives have been implemented in different countries (Liu etal., 2016), by individual brands[2] and by nonprofit organizations[3]. At this point in the developments and debate over carbon labeling, we believe that three important questions need to be addressed. First, can private parties provide sufficient and credible labels or should government bodies implement a carbon label? Second, how do different labeling schemes affect consumers' ability to identify food choices with reduced climate impact, and what is the expected impact on behavior? Third, what are the benefits and costs of a carbon label, and how is this affected by the labeling strategy?

Guided by theoretical evidence from economics and behavioral sciences, we address these questions. We combine the different elements that define a carbon labeling strategy in a grid, thereby laying out a structure for how the different aspects affect consumers' ability to identify products with reduced carbon emissions. By this, we aim to provide guidance to future research on carbon labeling, to ensure pertinent support to policy makers.

A number of reviews on food labeling provide guidance on the state of knowledge on labeling of a variety of sustainability-related aspects, including pesticide use and animal welfare, origin, labor conditions, breeding methods (Roe and Deans, 2014; Yokessa and Marette, 2019; Asioli et al., 2020). Carbon labeling is to a smaller extent included in reviews, likely due to the hitherto low market presence and the relatively recent increase in number of empirical studies on consumer preferences regarding climate impact. While some of the conclusions from the sustainability labeling reviews are relevant to the case of carbon labeling, we argue that carbon labeling is different from other sustainability labels in key aspects. Importantly, contrary to well-established sustainability labels such as organic, MSC and fair trade, carbon emissions are highly correlated with the product category, where emissions are higher from animal products compared to vegetable products. This implies additional challenges to how the labeling schemes should be defined.

[1] In Denmark https://www.foedevarestyrelsen.dk/Foedevarer/Klimamaerke

[2] Examples of carbon labels implemented by private brands include Quorn and Oatly https://www.ft.com/content/45dbe119-391b-41e5-8b6a-c6b5a082d062?shareType=nongift

[3] https://www.foundation-earth.org/

The remainder of the paper is organized as follows. Section 2 provides a background to the theory of labels while Section 3 discusses if a carbon labeling system should be mandated by government or if private initiatives are sufficient. Section 4 discusses key characteristics of a carbon label, including the assessment of the climate impact, the degree of detail in a label, and which types of comparisons a label enables (across vs. between food categories). Section 5 summarizes the different aspects of a labeling strategy in a grid and discusses the implications for the different combinations of label characteristics. Finally, Section 6 discusses the benefits and costs associated with carbon labeling, and how this is affected by the carbon labeling strategy while Section 7 discusses effects on the market structure, and Section 8 concludes.

2. Reducing climate impact; the role of informed choices

The provision of information as a measure to change consumers' purchase patterns is a demand-side instrument, which depends on consumer preferences regarding the quality in question, such that at least a share of consumers prefer lower emitting products to higher emitting variants, all else equal. Moreover, information as a policy instrument relies on that consumers' access and process the information and that there is product differentiation, such that at least a share of the producers supply the higher quality (lower emitting) variants (Bonroy and Constantatos, 2015). Consumers will search and evaluate information if the effort required does not exceed the benefits, such that the expected marginal return of information exceeds the expected marginal cost of searching for the information (Stigler, 1961). It is also of importance that the information is seen as reliable (Darby and Karni, 1973).

In the analysis of consumer preferences for food characteristics, a multi-attribute approach forms a theoretical point of departure (Lancaster, 1966). This implies that products are viewed as bundles of characteristics and that consumers derive utility from each of these characteristics (hereafter referred to as attributes). This approach is fundamental for much microeconomic analysis of consumer demand. Consumers are assumed to be utility-maximizing, and they will choose the product that provides the combination of price and quality attributes that is most consistent with their preferences and subject to their constraints. However, such a decision process, were all product attributes in a purchase situation are evaluated, can be costly in time and effort for the consumer. In choice tasks that are low involvement, which is often the case for food choices, consumers tend to rely on heuristics that facilitate the purchase decision (Kahneman, 2003; Hauser, 2014). In this context, food labels can simplify the information and assist consumers in the comparison of different products.

2.1 What type of quality is climate impact of a product?

The intrinsic qualities of food products can be in the form of *search* qualities, which the consumer can identify prior to purchasing, or *experience* qualities, which are only possible to identify after purchasing or consuming the product (Nelson, 1970). Finally, some qualities are not possible for consumers to detect even after consumption, and for such *credence* qualities, consumers must rely on other sources of information (Darby and Karni, 1973). Intrinsic attributes, particularly those in the form of experience and credence qualities, are disposed to situations of asymmetric information, where producers have more information than consumers about the qualities of their product. Consequently, consumers are not able to accurately judge the quality of the products and may consequently not purchase products that are most in line with their preferences (Akerlof, 1970; Golan et al., 2001).

Contrary to intrinsic quality attributes, extrinsic cues are not part of the physical product, but they may be interpreted as signals of quality. Extrinsic cues in the form of food labels can turn experience and credence quality attributes into search attributes, provided that they are perceived as credible (Caswell and Mojduszka, 1996). Hence, labeling can alleviate asymmetric information and enable consumers to make choices more in line with their preferences and reduce uncertainty regarding the nature of the product attributes (Teisl and Roe, 1998). Moreover, food labels can be of value for search qualities by making the information more accessible and, thereby, less costly for consumers to use, by requiring less cognitive effort (Caswell and Anders, 2011). Importantly, although extrinsic cues may be used as information about intrinsic qualities of a product, such cues vary in their accuracy. For instance, consumers may interpret brand, country of origin, type of packaging, and the price of a product as signals about the quality of the product (Steenkamp, 1989; Steenkamp and Trijp, 1996). In the case of climate impact, there is evidence that consumers believe that buying locally produced food or organic food is more effective in reducing climate impact compared to reducing meat consumption (de Boer et al., 2016). Hence, in the absence of credible carbon labels, consumers that wish to make climate-friendly food choices may use other extrinsic cues as information about climate impact.

The benefits and costs of a labeling system depend on the type of attribute it should inform about. In general, the benefits are larger for experience and credence qualities compared to search qualities, since it is more costly for the consumer to obtain this information (Teisl and Roe, 1998). The climate impact of a product has *both* search qualities and credence qualities. The exact amount of carbon emissions from the production of a product depends on aspects such as technology use, management practices, and place of production (Poore and Nemecek, 2018; Springmann et al., 2018). Such aspects are not possible for the consumer to evaluate upon inspection or consumption, and it is, hence, a credence quality. However, while there are variations in carbon emission equivalents *within* product categories, the main differences are *between* product categories (Poore and Nemecek, 2018). Thus, the climate impact compared between product categories is not a credence quality. For example, vegetable products have lower climate impact compared to animal products (e.g. vegetable oil has lower climate impact than butter, and pulses have lower impact than red meat). This suggests that carbon labeling can target information asymmetries *within*-product categories (credence qualities), while the usefulness of carbon labels *between* products is rather that the information becomes more salient and reduces the costs in the form of cognitive effort required by consumers. This distinction has implications for the expected benefits and costs of carbon labels, and thereby on the labeling strategy.

3. Ownership and mode of governance

Economic theory posits that if there are no costs of supplying information, and consumers trust the information, all producers except those with the lowest quality will voluntarily disclose the quality of their products. If such information is not disclosed, rational consumers will assume that a product has the lowest quality (Ippolito, 1990). This prediction relies on the assumption that consumers are aware of that the information exists and, importantly, that the quality in question is important to at least a share of consumers. Under these assumptions, voluntary labeling will provide sufficient information for consumers to make informed choices. However, depending on the level of detail of rating, carbon labeling can be costly. Therefore, widespread voluntary disclosure relies on a large demand from consumers for this type of information.

Broadly, labels can be implemented and regulated by three types of agents: private parties, independent third parties, and government. Private parties, such as private firms and collectives of firms, can provide labels or claims based on self-declared standards. The motivation for these agents is to support product differentiation and target consumers who are willing to pay for the characteristic in question. There are several examples of such private carbon labels (Liu et al., 2016).

Labels can also be certified by independent third parties, such as NGOs, typically with the intention of promoting sustainable food consumption. Independent third party labeling can both target and shape consumer demand. An example of this is the dolphin safe label, which put an environmental problem in the spotlight, and raised awareness among consumers (Teisl et al., 2002). Independent third parties, particularly NGOs, tend to have higher credibility among consumers compared to private parties (Roe and Teisl, 1998). Although the motives for labeling initiatives provided by private actors and independent third party NGOs vary, they are all voluntary for producers to display.

In cases where private or third party labeling is not credible, government labeling may be mandated (Sunstein, 2017), to protect consumers from fraud by overseeing standards and certifications. Many countries have government-certified organic labels that are voluntary for producers to display and motivated by a desire to prevent fraud (Golan et al., 2001). Public labeling programs can also be motivated as a measure to combat confusion, as many different sustainability-related labels have emerged on the market in the past decade.

In general, two economic situations motivate public mandatory labeling: First, when the unregulated market does not provide sufficient information for consumers to make decisions in line with their preferences. This motive for alleviating asymmetric information is not to change consumption, but to make consumers' decisions more informed (Golan et al., 2001). An example is that it is mandatory to display the nutritional content on products in many countries (FDA, 1994; EU, 2011). Second, and importantly for the case of climate impact, mandatory public labeling can be mandated to target externalities. When a quality is a public good, demand is societal rather than private. This implies that consumers in an unregulated market do not personally experience the full costs from consumption. In such cases, the unregulated market typically undersupplies the quality if it is a positive externality and oversupplies the quality if it is a negative externality such as CO_2 emissions (Caswell and Anders, 2011). Mandatory labeling can then serve as an instrument to affect consumption, but we note that it relies on consumers' preferences and willingness to pay for the public good.

4. Carbon label characteristics

Generally, carbon labels on the market and in experimental studies fall into four categories (Thøgersen and Nielsen, 2016): (i) Labels that provide information about the CO_2 equivalents emitted from a unit of the product, based on lifecycle analysis. (ii) A symbol that indicates that the product is low in carbon emissions. The criteria that the certifying agent applies are typically not presented to the consumer at the point of purchase. (iii) Labels declaring that the producer has committed to reduce emissions. This type of label does not inform about the absolute level of emissions, but rather about an improvement compared to historical levels. This type of label is potentially most beneficial for high emitting producers that have more room for improvement. (iv) Carbon neutrality was the carbon emissions caused by the production of the product that has been compensated by the company, for example by paying for forestation (Thøgersen and Nielsen, 2016). In the following, we focus on labels that inform consumers about carbon emissions from the product in some form. The third and fourth types of labels are not related to the absolute emission levels and are hence not educative for the consumer. Since a shift in consumption patterns is needed to achieve significant reductions in emissions from food, we will focus on the first two label types only.

4.1 Assessment

Assessment refers to how a label communicates the climate impact of a product, and it can be described on a continuous scale ranging from purely descriptive label types to fully evaluative label types. In between these, extremes are many possible variants. A label that is purely descriptive displays the exact amount of carbon emissions (CO_2 equivalents) from the production of one unit of the product, hereafter referred to as a Digit (D) label. This Digit label is comparable to nutrition tables that are mandatory in many countries (FDA, 1994; EU, 2011). The Digit label lessens the asymmetric information and enables consumers to compare products and evaluate the climate impact both *within*- and *between*-product categories. Yet, if information requires high involvement and cognitive abilities, consumers may judge it too costly to retrieve.

A purely descriptive Digit label can be made evaluative by relating the digit to a reference level. Evaluative labels decrease these costs for consumers by reducing the cognitive effort and time required to make informed choices. Examples of such labels include the Guideline Daily Amounts and the Multiple Traffic Light label (FSA, 2020), which show the key nutrients and energy, expressed in percentage related to daily reference intake. A Reference Intake (RI) type of carbon label could express the emissions as a percentage of the amount of carbon emissions per person allowed from food, should the targets in the Paris Agreement be successful, as the reference intake. The benefit of relating information to reference levels is supported in a survey in the US, where respondents found a carbon label on food easier to comprehend when the emissions were translated into how many light bulb hours they corresponded to Camilleri et al. (2019). A further step in the direction of more evaluative carbon labels is to indicate if the digit is low or high, by showing the carbon emissions on a color scoring system (CSS), where the Digit is placed on a color scoring scale from green to red.

The most evaluative types of labels do not allow consumers to make detailed comparisons, but relies on a set of criteria specified by the label provider. This can be in the form of traffic light systems (TLS), indicating if a product is red, amber, or green, or in the form of a single logo (L), which is only displayed on the products that fulfill the criteria.

Logos can be either in positive form, indicating that a product has a low carbon footprint, or a negative label, in the form a warning message. Importantly, the framing of information can affect consumer choices. Prospect theory asserts that losses are valued more negatively than corresponding gains are valued positively (loss aversion) (Kahneman and Tversky, 1979). Relatedly, individuals tend to place more attention to negative information than positive information (negativity bias) (Rozin and Royzman, 2001), suggesting that how the information in a food label is framed affects the perception and impact on consumer choices. Empirical evidence supports these predictions, showing that negative (warning) labels have a larger effect compared to positive labels (Grankvist et al., 2004).

4.2 Detail of rating

The detail of rating describes the degree of differentiation between products that a label enables. The detail of rating ranges from continuous scales to binary ratings. Similar to the

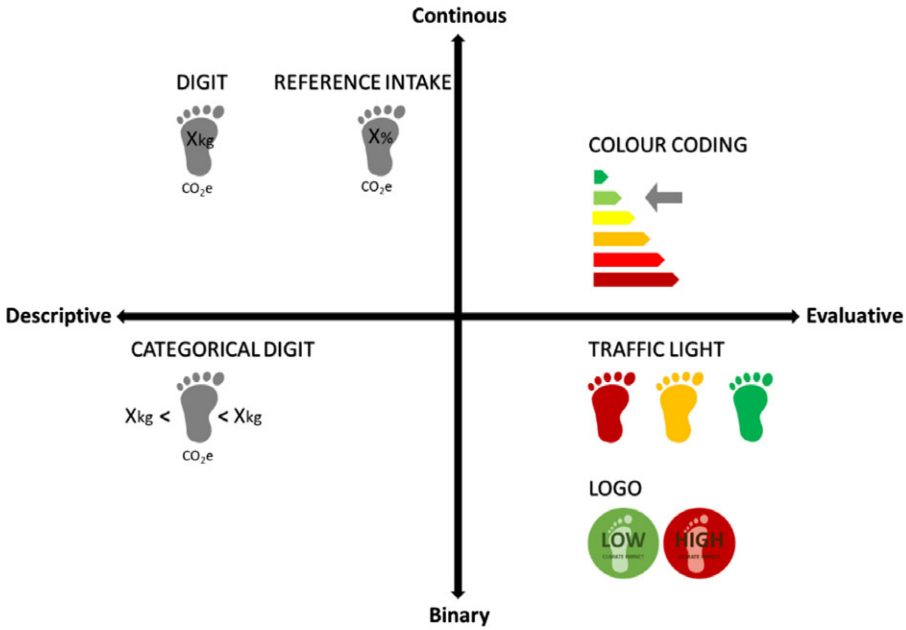

Figure 1. Assessment and detail of rating.
Note: Assessment ranges from Descriptive to Evaluative (horizontal axis). Detail of rating ranges from Binary to Continuous (vertical axis).

Assessment dimension, the Detail of rating dimension is related to the ease of use and understanding for the consumer. Both dimensions are illustrated in Figure 1. Among existing food labels related to health and sustainability, there is a correlation between the detail of rating and the type of assessment, although such correlation is not necessary. While purely descriptive labels (D) commonly are in continuous forms, these values can be presented in a categorical form, to reduce the cost on producers and certifiers of measuring precise values. The categorical form will also reduce the cognitive burden for the consumers. Evaluative labels are commonly in the form of traffic light systems or logos, although the EU energy label is an example of an evaluative label in a detailed format (European Commission, n.d.).

The type and volume of information on a label will affect the amount of time and effort required, in order to evaluate product attributes. In general, consumers find categorical labels easier to understand and use compared to continuous scales (Loewenstein et al., 2014). There is also evidence that consumers prefer the less detailed nutrition and health labels and that consumers are more successful in identifying healthy products when using labels with fewer categories (Campos et al., 2011). Hence, more information is not always better, as this increases the likelihood that consumers do not find it worthwhile to spend time and effort to use the information and rather choose to ignore it. Taken together, theory does not guide on the optimal amount of information and level of detail, as this likely varies between individuals and products, depending on their prior knowledge, cognitive ability, interest, and preferences for the attribute that the label concerns (Teisl and Roe, 1998).

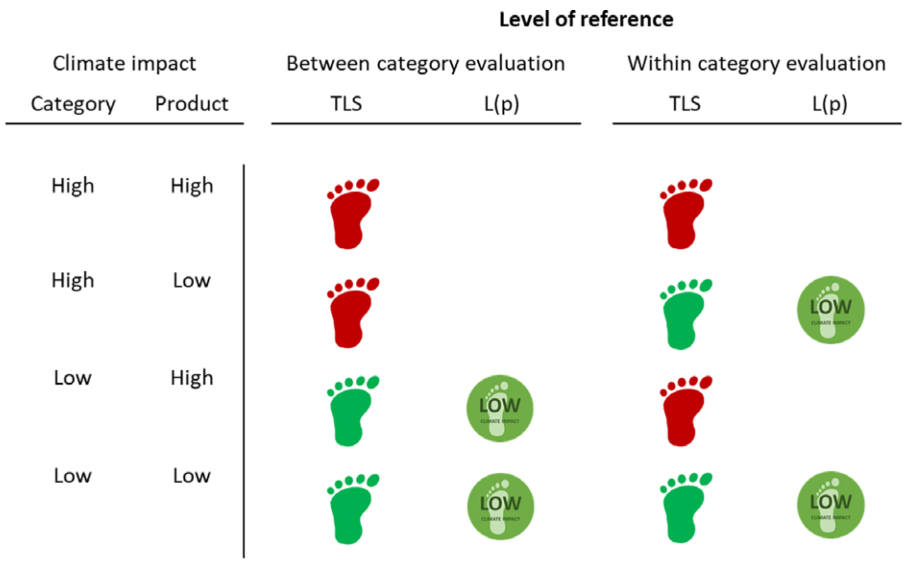

Figure 2. Level of Reference for evaluative labels.
Note: TLS=Traffic Light System, L(p)=Logo (positive). Red footprint indicates high emissions, and green footprint indicates low emissions. Amber footprint indicates medium high emissions, but is not included in this simplified example.

4.3 Level of reference

For all labels that are evaluative to any degree, there must be a level of reference. This implies that a subjective judgment must be made on how the reference is defined. For example, how should the reference intake be calculated for the reference intake (RI) type of label? Which thresholds should be used for the traffic light system (TLS)? And which requirements should there be for the display of a positive low carbon logo, L(p), or a negative warning logo, L(w)? The choice of level of reference has important implications for which type of information the consumers retrieve from a label. This is particularly decisive for the most evaluative labels such as TLS and L labels, which identify if a product fulfills certain criteria. In particular, it must be decided if these criteria identify carbon emissions thresholds that apply across all products or if there should be different thresholds within each food category. For the purpose of illustration, we assume two product categories: one high emitting and one low emitting product category. The high emitting category can be red meat, while the low emitting category can be crop based. Further, we assume two products in each category: one high emitting variant and one low emitting variant. This depends on aspects such as technology in production and management practices and can therefore not be evaluated by the consumer upon inspection or consumption. The implications from the choice of reference are illustrated in Figure 2.

As visible in the middle column of Figure 2, labels with *between*-category evaluation inform about the overall emission levels. This type of label informs consumers about large differences. A comparison to the health label area could be that unhealthy categories such as soda, chips, and candy are labeled with red TLS labels (or cannot display the positive logo), while all products in healthy categories, such as vegetables, are labeled with green TLS labels or displays the positive logo. An important benefit with the *between*-category evaluation is that it is educative, as consumers will learn about the larger differences in emissions. Largely, the same information could be disseminated without specific product labels, as the *between*-category evaluation could be communicated in general information campaigns, in posters in the purchase setting, and through educational efforts in other environments. Yet, while this is true in general terms, and regarding the large differences between product categories, the large number of product categories available in many grocery stores implies that it will be challenging to communicate the necessary information through general campaigns only.

For the *within*-category evaluation type of label (right column in Figure 2), consumers are informed about the relative climate impact within a specific category. The information conveyed with this level of reference type is more likely to be a credence quality; consumers cannot judge upon inspection or consumption if the product is low or high in emissions compared to other similar products. For this reason, contrary to a between-category evaluation, the information conveyed from within-category evaluation is not possible to provide in general information campaigns. Importantly, the information is less educative compared to the between-category evaluation, in the sense that consumers will not learn about which type of substitutions that have the largest impact on their climate impact. Since today's consumers usually buy a mix of food products, from both high and low emitting product groups, *within*-category labeling can still have an important impact on consumer choices and carbon emissions. Consumers usually find it easier to substitute products within a product group than between products in different product groups. The within-category evaluation type of label is available in the health area, including the health-tick, the Nordic keyhole, and the Choices logo, where consumers are informed about the healthier choice within a certain category. Notably, the literature that evaluates the effects of these label focus on within-category substitutions, and not on larger improvements toward healthy diets, a shortcoming that has been noted in the literature (Nikolova and Inman, 2015). As can be seen from Figure 2, low emitting products within both high and low emitting categories will have the same logo.

In addition to the type of assessment, the level of detail, and the choice of reference level, other label characteristics related to the appearance of the label can affect the attention and use of the label. For example, front of pack food labels with more color receive more attention, and the placement on the package, and how many other labels there are on the product also affect attention and use of labels. Hence, these aspects are of relevance in the design of a label and for producers in the decision on how and where to display a label (Graham et al., 2012).

5. How does labeling strategy affect consumer perception?

Both the mode of governance and the labeling characteristics will affect the type and amount of information a carbon label provides. For illustration, we extend on the example with two food categories presented in Figure 2. The columns in Figure 3 represent different types of assessment and varying degree of details of rating, ranging from the purely descriptive and continuous Digit label to the fully evaluative and binary labels (logos). Further, the evaluative labels vary by the level of reference, including both *between*- and *within*-category evaluation. The two vertical panels in Figure 3 represent the mode of governance, with voluntary and mandatory labeling.

Figure 3 illustrates that with voluntary labeling, only the low emitting products will display information. This holds across different types of assessment, details of rating, and levels of reference. Rational and sophisticated consumers will infer that the absence of low carbon emission labels implies that a product is high in carbon emissions (Ippolito,

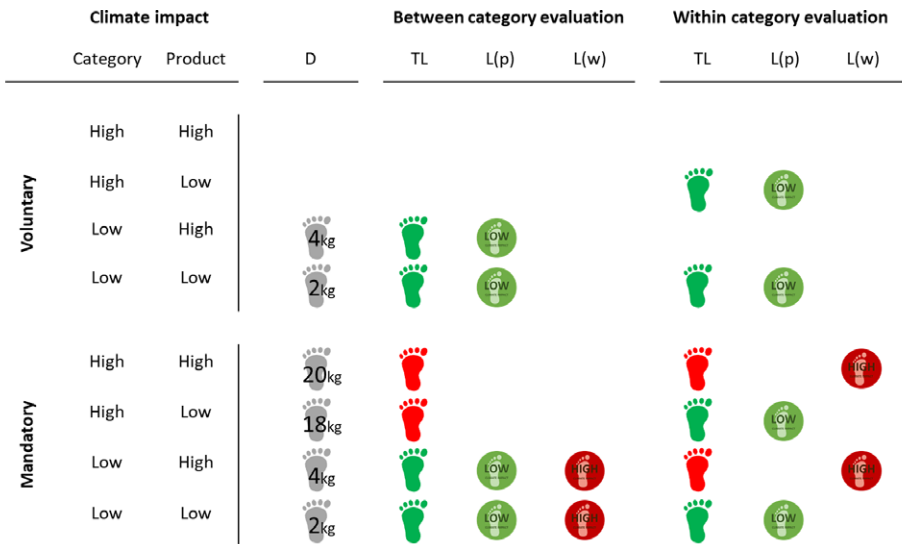

Figure 3. Dimensions of carbon labeling systems.
Note: D = Digit, RI = Reference Intake, TLS = Traffic Light System, L(p) = Logo(positive), L(w) = Logo(warning).

1990). If this assumption holds, private and voluntary labeling should be sufficient. Yet, if consumers lack this awareness, or fail to make the conclusions, voluntary labels are not sufficient, and mandatory labeling is justified (Loewenstein et al., 2014). In sum, given that climate impact is a public good and that consumers may not make the inference from the absence of labels, mandatory carbon labeling is likely needed to ensure that sufficient information is provided to enable consumers to make informed choices.

Mandatory labeling, which includes all products, is expected to have a larger impact on consumer behavior since such labeling systems also identify products with high emissions. As mentioned, consumers tend to react more strongly to negative information than to positive information. Inspection of the mandatory labeling (lower panel of Figure 3) reveals that the most descriptive and detailed label formats (Digit and Reference Intake) provide greater amount of information and enables comparison both *between* and *within* categories. For evaluative labels, the choice of reference level greatly affects the type of evaluation consumers can make from the label. There is a big difference between mandatory *between*-category and *within*-category evaluative labels, if one considers total CO_2 emissions. The last three columns in Figure 3 show that the within-category evaluative logos provide the consumer with exactly the same information for products with high and low climate impact, although their climate impact is very different. Hence, consumers must be knowledgeable about that such within-category labels only guide decision within categories and that it is not to be used for substitution decisions between categories.

6. Benefits and costs of labeling

When deciding on labeling strategy, policy makers should weigh the benefits against the costs of labeling, and how these are distributed (Golan et al., 2001; Sunstein, 2017). For consumers, the main benefit of a labeling is that they are enabled to make informed choices, which are in line with their preferences. The social benefits from carbon labeling depend on the reductions in carbon emissions that the labeling program achieves. Such effects on carbon emissions, hence, depend on the changes in consumption that occur after the label is implemented, which in turn depends on consumers' preferences.

If few consumers have interest in making choices that are low in carbon emissions, and if they do not value this much, the labeling benefits will be small. Policy makers can be informed about this by quantifying consumers' willingness to pay for reduced carbon emissions. Consumer valuation studies, where the willingness to pay is measured in experimental studies, can be used for estimating this (Sunstein, 2017). Experimental studies have found support for a positive willingness to pay for products that are lower in carbon emissions, but the climate impact is relatively unimportant for most consumers compared to other food qualities (Rondoni and Grasso, 2021). A challenge with this approach is that since carbon labeling has not been implemented on a large scale, it may be difficult for consumers to evaluate the use and benefits with carbon labeling (Sunstein, 2021; Reisch et al., 2021). Ex post estimates of the willingness to pay for carbon labeling may therefore give better assessments, and this could be done via lab or field experiments (Sunstein 2021). Further, it is of relevance for policy makers to reflect on the distribution of willingness to pay among consumers.

One potential benefit from labeling is education. This is particularly true for government-mandated labeling with a labeling format that enables comparison between product categories. While general knowledge about carbon emissions from different product categories is possible to communicate in other channels, such as information campaigns and dietary guidelines, consumers may find it difficult or misinterpret the connection in the purchase situation. Hence, for information that is in the between-category evaluation format, mandatory labeling could be motivated by a need to make such information more salient and easier to access (Teisl and Roe, 1998). As a sustainability education intervention, mandatory carbon labels could have a broad reach if they are displayed on products, as they will be presented to consumers upon purchase, but also when food is prepared and consumed. The information may also affect the social norm such that this information becomes more demanded and important for consumers in their purchase decisions.

A further benefit that may arise from government-mandated labeling is that it can motivate producers to reduce their emissions to obtain labels that are more favorable. Evidence from other areas shows that the implementation of mandatory calorie information disclosure caused restaurants to make their menus healthier, and when an energy efficiency label was mandated, the energy efficiency innovations increased substantially (Golman et al., 2017). Labeling benefits in the form of reformulation effects are more likely to occur if the more descriptive (D and RI) or the evaluative within-category evaluation types of labels are implemented. For example, a producer of high emitting products in the high emitting category can change technology and management practices to reduce emissions and improve their digit, RI or obtain a positive within-category logo. In contrast, a between-category evaluation will not enable producers in the high emitting categories to obtain a positive logo by technological advances, since emission levels are connected to the product category.

Finally, if firms anticipate stringent requirements in the future, such as implementation of a carbon tax or regulations of maximum amount of carbon emissions per product, they may voluntarily display carbon labels. By voluntarily displaying, and improving their formulas, they show to the consumers (and policy makers) that they are making an effort in the area. This potential benefit from a carbon label is, however, difficult to measure (Yokessa and Marette, 2019).

Labeling is also associated with costs for consumers, producers, and the certifying body. For consumers, the time and effort required for searching and interpreting the label is associated with alternative costs (it could be used for something else). The more evaluative labels are less costly for the consumer to interpret compared to the most descriptive and detailed label formats. Moreover, the introduction of a carbon label can contribute to choice overload, where the number of sustainability-related labels is already high (Cohen and Vandenbergh, 2012; Brown et al., 2020). An overload of labels may thus contribute to reduced benefits from other labels. Information may also create a psychological cost or discomfort for consumers (Thunström et al., 2016, 2014; Nordström et al., 2020). If climate information causes consumers great disutility, this could constitute a non-marginal cost, and alternative policy instruments may be regarded more socially optimal (Golman et al., 2017).

Further, while producers face labeling costs associated with providing information related to administration, testing, reformulation, printing, and certifying bodies face costs of enforcing and controlling label use, such costs may be forwarded to the consumers (Golan et al., 2001; Crespi and Marette, 2003). With voluntary labeling schemes, the cost falls on the labeled products, while mandatory labeling will distribute the costs among all products. It is thus important to take distributional aspects of the labeling costs into account when evaluating different labeling schemes. Importantly, the dimensions of a carbon label will influence the costs, where the cost for a digit type of label is relatively high, since it is based on life cycle analysis. The early experiences from such labels by Tesco highlight that such costs are considerable (Vaughan, 2012). The evaluative labels can be assumed to be cheaper to implement since these labels do not require the same degree of detailed information.

In addition, the benefits of carbon labeling depend on the consumers' behavioral changes and associated reduction in the carbon footprint. As this can be difficult to estimate a priori, well-designed field studies can provide valuable information before decisions about mandatory carbon labeling are taken.

7. Effects from carbon labeling on market structure

The implementation of a credible carbon label enables firms producing higher quality (lower emitting) products to differentiate their products from that of lower quality competitors. Importantly, the introduction of a mandatory or voluntary label may affect the market structure, by affecting different types of firms differently.

The costs associated with a carbon label are one aspect that may result in changes in the market structure. Costs for firms associated with a labeling scheme consist of certification costs and costs for producing products that fulfill requirements for displaying a high-quality label. Cost for certification can be fixed or variable, where fixed costs may burden smaller firms disproportionally, leaving them disadvantaged relative to larger firms (Golan et al., 2001). Fixed costs may also work as an entry barrier for new firms. Further, the costs for firms to achieve higher quality products may affect firms differently. Reducing carbon emissions, and thus fulfilling the requirements for a binary logo or higher levels on a multi-level label, may be fixed (e.g. investing in R&D or new technology) or variable (increased reliance on low emitting input) (Roe and Deans, 2014).

In addition to costs associated with labeling, firm welfare effects and implications on the market structure depend on a number of aspects, including the market structure prior to the introduction of a label, the design of the labeling scheme, and the preference structure among consumers (Bonroy and Constantatos, 2015; Sheldon, 2017). In the industrial organization literature on food labeling, it is typically assumed that there are high-quality and low-quality products, and this is a scenario that describes how many credence qualities are represented on the market (e.g. organic, non-GMO, MSC, locally produced). Consumers are assumed to prefer the high quality, but have different willingness to pay for it. In the case of carbon impact, this holds if a within-category evaluative type of labeling scheme is applied. All else equal, consumers can be assumed to prefer lower emitting product variants but their willingness to pay for lower emissions and the cost of labeling is an empirical question that needs to be studied before firm conclusions can be given on the market outcome (see e.g. the results in Mattoo and Singh (1994)). Looking at the marker structure as such, results in Zago and Pick (2004) indicate that if the labeled high-quality sub-market remains sufficiently competitive, the introduction of a labeling scheme is welfare improving. However, if the introduction of labeling increases concentration in the sub-market, it reduces welfare. Bonroy and Constantatos (2015) study the welfare effects of labeling under price competition and find that labeling is welfare improving (under a uniform consumer distribution), driven by higher profits for the firms. It is thus case-specific whether a labeling reform will improve or reduce welfare, and this requires ex post analysis. We note that the external benefit of lower CO_2 emissions is not accounted for in these studies, and since this is an important motivation for introducing mandatory carbon labeling, it should be included in the overall welfare analysis.

8. Discussion and policy implications

An important motivation for carbon labeling is to increase social welfare by targeting negative externalities. Compared to other political instruments that aim to shift consumer behavior, the implementation of information is perhaps the least controversial. One attractiveness with information disclosure is that it does not directly intervene with the free market principles. From a government's perspective, labeling systems may thus be politically more feasible to implement compared to other regulations. However, to achieve the needed changes in food consumption patterns to reach the targeted reductions in climate impact, more direct measures, such as restrictions on emission levels or taxation, are generally more effective (Golan et al., 2001). Hence, the costs and benefits from a mandatory labeling regime should be evaluated against other instruments. Moreover, there may be important interaction effects from implementing more than one policy instrument. The effect of food labels is likely affected by if it is integrated in other educational programs (Caswell and Padberg, 2010). For example, if a mandatory carbon label is implemented, the effects are likely larger if the information contained is also communicated as dietary advice in schools, national dietary recommendations, and other forms of public information campaigns. Moreover, insights from behavioral economics, including choice environment design, could also play an important role in shifting consumption patterns (Grolleau et al., 2016). While synergies between different interventions and instruments aiming to reduce climate impact from food consumption hold great promise, the insights on these matters are very limited, and this is an interesting area for future research.

We identified a need for insights on how the labeling strategy and characteristics of the label will impact labeling effects. While there is much research regarding other food labels that can provide guidance for carbon labeling, the climate impact from food constitutes a distinctly different type of quality compared to other well-known sustainability-related labels such as organic, MSC, fair trade, and GMO. First, these types of labels inform consumers about credence qualities for a specific product within a product category, while for climate impact the main differences are between product categories. This implies that substitutions between product categories are required if consumers should contribute to a significant reduction in carbon emissions. Given that food choices are largely guided by habits, taste preferences, norms, and traditions, the changes required from a climate perspective are more demanding for consumers. Second, while climate impact is a purely public good, several other sustainability labels are semi-public, as an important motivation for purchasing organic is that it is perceived as healthier, and even tastier (Hughner et al., 2007; Schuldt and Schwarz, 2010). Taken together, decisions regarding carbon labeling cannot rely entirely on insights from other areas of food labeling.

We find that descriptive and detailed labeling that enables comparison both between-product categories and within-product categories provides consumers with the best opportunity to choose along their preferences. Yet, the cost of using such labels is high for consumers, and empirical studies are needed that evaluate the optimal degree of detail and evaluative level. For evaluative labels, the level of reference has key implications for the type of information consumers retrieve from a carbon label. Importantly, if a carbon labeling scheme is to enable consumers to make informed choices and changes in consumption that cause significant reductions in CO_2 emissions, a carbon label must be present on a broad level and not in narrowly defined product groups. This poses a challenge if labeling is voluntary, as producers of high-emission products are less likely to include such labels. A labeling system that combines the advantaged of a between- and within-category labeling system may thus be of interest to evaluate in the future. Such a label would create incentives for producers to improve their technologies and reduce emissions, and it would also inform consumers about both high and low emitting categories and low and high emitting alternatives within the category. This creates incentives to substitute between-product categories as well as within-product categories.

Regarding the ownership and mode of governance, we note that a mandatory labeling scheme, where all products are labeled, will have greater impact on consumer choice compared to voluntary labels. However, before a mandatory carbon labeling scheme is implemented, it is of importance to evaluate the cost and benefits of the labeling scheme. This calls for empirical evidence, including consumer willingness to pay estimates that enable comparisons across labeling types.

Finally, while carbon emissions are the focus of this study, other sustainability aspects such as biodiversity (Röös et al., 2014), nitrogen, and water use may be incorporated in a labeling program (Leach et al., 2016). While including more aspects increases complexity, and consequently costs, this is an interesting area for future research.

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References

Akaichi, F., C.R. Giha, K. Glenk, and J.M. Gil. 2020. "How consumers in the UK and Spain value the coexistence of the claims low fat, local, organic and low greenhouse gas emissions." *Nutrients* **12**(120).

Akerlof, G.A. 1970. "The market for 'Lemons': Quality Uncertainty and the market mechanism." *The Quarterly Journal of Economics* **84**(3): 488–500.

Apostolidis, C., and F. McLeay. 2016. "Should We Stop Meating like This? Reducing Meat Consumption through Substitution." *Food Policy* **65**: 74–89.

Asioli, D., J. Aschemann-witzel, and R.M. Nayga Jr. 2020. "Sustainability-related food labels." *Annual Review of Psychology* **12**: 171–185.

Bonroy, O., and C. Constantatos. 2015. "On the economics of labels: How their introduction affects the functioning of markets and the welfare of all participants." *American Journal of Agricultural Economics* **97**(1): 239–259.

Brown, K.A., F. Harris, C. Potter, and C. Knai. 2020. "The future of environmental sustainability labelling on food products." *The Lancet Planetary Health* **4**(4): e137–e138.

Camilleri, A.R, R.P. Larrick, S. Hossain, and D. Patino-Echeverri. 2019. "Consumers underestimate the emissions associated with food but are aided by labels." *Nature Climate Change* **9**: 53–59.

Campos, S., J. Doxey, and D. Hammond. 2011. "Nutrition labels on pre-packaged foods: A systematic review." *Public Health Nutrition* **14**(8): 1496–1506.

Canavari, M., and S. Coderoni. 2020. "Consumer stated preferences for dairy products with carbon footprint labels in Italy." *Agricultural and Food Economics* **8**(1): 1–16.

Carlsson, F., M. Kataria, E. Lampi, E. Nyberg, and T. Sterner. 2021. "Red, yellow, or green? Do consumers' choices of food products depend on the label design?" *European Review of Agricultural Economics*, August, jbab036. https://doi.org/10.1093/erae/jbab036.

Caswell, J.A., and S.M. Anders. 2011. "Private versus Third Party versus Government Labeling." In *The Oxford Handbook of The Economics of Food Consumption and Policy*, edited by J.L. Lusk, J. Roosen, and J.F. Shogren, 473–498. Oxford: Oxford University Press.

Caswell, J.A., and E.M. Mojduszka. 1996. "Using informational labeling to influence the market for quality in food products." *American Journal of Agricultural Economics* **78**(5): 1248–1253.

Caswell, J.A., and D.I. Padberg. 2010. "Toward a More comprehensive theory of food labels." *American Journal of Agricultural Economics* **74**(2): 460–468.

Cohen, M.A., and M.P. Vandenbergh. 2012. "The potential role of carbon labeling in a green economy." *Energy Economics* **34**(Suppl.1): S53–S63.

Crespi, J.M., and S. Marette. 2003. "Some economic implications of public labeling." *Journal of Food Distribution Research* **34**(3): 83–94.

Darby, M.R., and E. Karni. 1973. "Free competition and the optimal amount of fraud." *The Journal of Law and Economics* **16**(1): 67–88.

de Boer, J., A. de Witt, and H. Aiking. 2016. "Help the climate, change your diet: A cross-sectional study on how to involve consumers in a transition to a low-carbon society." *Appetite* **98**: 19–27.

Edenbrandt, A.K., and C.-J. Lagerkvist. 2021. "Is food labelling effective in reducing climate impact by encouraging the substitution of protein sources?" *Food Policy* **101**(May): 102097. https://doi.org/10.1016/j.foodpol.2021.102097.

Edenbrandt, A.K., C.J. Lagerkvist, and J. Nordström. 2021. "Interested, indifferent or active information avoider of climate labels: Cognitive dissonance and ascription of responsibility as motivating factors." *Food Policy*, 102036. https://doi.org/https://doi.org/10.1016/j.foodpol.2021.102036.

Elofsson, K., N. Bengtsson, E. Matsdotter, and J. Arntyr. 2016. "The impact of climate information on milk demand: Evidence from a field experiment." *Food Policy* **58**: 14–23.

EU. 2011. *Regulation (EU) No 1169/2011*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02011R1169-20180101.

European Commission. n.d. "Energy Label and Ecodesign." Accessed January 18, 2022. ec.europa.eu/info/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/energy-label-and-ecodesign_en.

FDA. 1994. "Nutrition labeling and education act (NLEA) requirements." https://www.fda.gov/nutrition-labeling-and-education-act-nlea-requirements-attachment-1.

Feucht, Y., and K. Zander. 2017. "Consumers' Willingness to pay for climate-friendly food in European countries." *International Journal on Food System Dynamics*, 360–377.

FSA. 2020. "The Eatwell Guide." Accessed January 18, 2023. https://www.food.gov.uk/sites/default/files/media/document/eatwell-guide-master-digital.pdf.

Godfray, H.C.J., P. Aveyard, T. Garnett, J.W. Hall, T.J. Key, J. Lorimer, R.T. Pierrehumbert, P. Scarborough, M. Springmann, and S.A. Jebb. 2018. "Meat consumption, health, and the environment." *Science (New York, N.Y.)* **361**(6399). https://doi.org/10.1126/science.aam5324.

Golan, E., F. Kuchler, and L. Mitchell. 2001. "Economics of food labeling." *Journal of Consumer Policy*, 117–184.

Golman, R., D. Hagmann, and G. Loewenstein. 2017. "Information avoidance." *Journal of Economic Literature* **55** (1): 96–135.

Graham, D.J., J.L. Orquin, and V.H.M.M. Visschers. 2012. "Eye tracking and nutrition label use: A review of the literature and recommendations for label enhancement." *Food Policy* **37**(4): 378–382.

Grankvist, G., U. Dahlstrand, and A. Biel. 2004. "The impact of environmental labelling on consumer preference: Negative vs. positive labels." *Journal of Consumer Policy* **27**: 213–230.

Grolleau, G., L. Ibanez, N. Mzoughi, and M. Teisl. 2016. "Helping eco-labels to fulfil their promises." *Climate Policy* **16**(6): 792–802. https://doi.org/10.1080/14693062.2015.1033675.

Grunert, K.G., S. Hieke, and J. Wills. 2015. "Sustainability labels on food products: Consumer motivation, understanding and use." *Food Policy* **44** (2014): 177–189.

Hauser, J.R. 2014. "Consideration-set heuristics." *Journal of Business Research* **67**: 1688–1699.

Hughner, R.S., P. McDonagh, A. Prothero, C.J. Shultz II, and J. Stanton. 2007. "Who are organic food consumers? A compilation and review of why people purchase organic food." *Journal of Consumer Behaviour* **6**: 1–17.

Ippolito, P.M. 1990. "The regulation of science-based claims in advertising." *Journal of Consumer Policy* **13**: 413–445.

Just, D.R, and A.T. Byrne. 2019. "Evidence-based policy and food consumer behaviour: How empirical challenges shape the evidence." *European Review of Agricultural Economics*, 1–23.

Kahneman, D. 2003. "Maps of bounded rationality: Psychology for behavioral economics." *The American Economic Review2* **93** (5): 1449–1475.

Kahneman, D., and A. Tversky. 1979. "Prospect theory: An analysis of decision under risk." *Econometrica* **47**(2): 263–291.

Lancaster, K.J. 1966. "A new approach to consumer theory." *Journal of Political Economy* **74**(2): 132–157.

Leach, A.M., K.A. Emery, J. Gephart, K.F. Davis, J.W. Erisman, A. Leip, M.L. Pace, et al. 2016. "Environmental Impact food labels combining carbon, nitrogen, and water footprints." *Food Policy* **61**: 213–223.

Liu, T., Q. Wang, and B. Su. 2016. "A review of carbon labeling: Standards, implementation, and impact." *Renewable and Sustainable Energy Reviews* **53**: 68–79.

Loewenstein, G., C.R. Sunstein, and R. Golman. 2014. "Disclosure: Psychology changes everything." *Annual Review of Economics* **6**: 391–419. https://doi.org/10.1146/annurev-economics-080213-041341.

Lohmann, P.M, E. Gsottbauer, A. Doherty, and A. Kontoleon. 2022. "Do carbon footprint labels promote Climatarian diets? Evidence from a large-scale field experiment." *Journal of Environmental Economics and Management* **114**: 102693. https://doi.org/https://doi.org/10.1016/j.jeem.2022.102693.

Lombardi, G.V., R. Berni, and B. Rocchi. 2017. "Environmental friendly food. Choice experiment to assess consumer's attitude toward 'climate neutral' milk: The role of communication." *Journal of Cleaner Production* **142**: 257–262.

Mattoo, A., and H.V. Singh. 1994. "Eco-labelling: Policy considerations." *Kyklos* **47**(1): 53–65.

Meyerding, S.G.H., A.L. Schaffmann, and M. Lehberger. 2019. "Consumer preferences for different designs of carbon footprint labelling on tomatoes in Germany-does design matter?" *Sustainability* **11**(1587). https://doi.org/10.3390/su11061587.

Moran, D., R. Wood, E. Hertwich, K. Mattson, J.F.D. Rodriguez, K. Schanes, and J. Barrett. 2020. "Quantifying the potential for consumer-oriented policy to reduce European and foreign carbon emissions." *Climate Policy* **20**(Suppl. 1): S28–S38. https://doi.org/10.1080/14693062.2018.1551186.

Nelson, P. 1970. "Information and consumer behavior." *Journal of Political Economy* **78**(2): 311–329.

Nikolova, H.D., and J.J. Inman. 2015. "Healthy choice: The effect of simplified point-of-sale nutritional information on consumer food choice behavior." *Journal of Marketing Research* **52**(6): 817–835.

Nordström, J., L. Thunström, K. van't Veld, J. F. Shogren, and M. Ehmke. 2020. "Strategic ignorance of health risk – Its causes and policy consequences." *Behavioral Public Policy*, 1–32.

Onozaka, Y., and D.T. McFadden. 2011. "Does local labeling complement or compete with other sustainable labels? A conjoint analysis of direct and joint values for fresh produce claim." *American Journal of Agricultural Economics* **93**(3): 689–702.

Peschel, A.O., C. Grebitus, B. Steiner, and M. Veeman. 2016. "How does consumer knowledge affect environmentally sustainable choices? Evidence from a cross-country latent class analysis of food labels." *Appetite* **106**(November): 78–91. https://doi.org/10.1016/J.APPET.2016.02.162.

Poore, J., and T. Nemecek. 2018. "Reducing Food's environmental impacts through producers and consumers." *Science* **360**: 987–992.

Reisch, L.A., C.R. Sunstein, and M. Kaiser. 2021. "What do people want to know? Information avoidance and food policy implications." *Food Policy* **102**: 102076.

Roe, B., and M.F. Teisl. 1998. "The economics of labeling: An overview of issues for health and environmental disclosure." *Agricultural and Resource Economics Review* **27**: 140–150.

Roe, M.F.T., and C.R. Deans. 2014. "The economics of voluntary versus mandatory labels." *Annual Review of Resource Economics* **6**(1): 407–427. https://doi.org/10.1146/annurev-resource-100913-012439.

Rondoni, A., and S. Grasso. 2021. "Consumers behaviour towards carbon footprint labels on food: A review of the literature and discussion of industry implications." *Journal of Cleaner Production* **301**(June): 127031.

Röös, E., L. Ekelund, and H. Tjärnemo. 2014. "Communicating the environmental impact of meat production: Challenges in the development of a Swedish meat guide." *Journal of Cleaner Production* **73**: 154–164.

Rozin, P., and E.B. Royzman. 2001. "Negativity bias, negativity dominance, and contagion." *Personality and Social Psychology Review* **5** (4): 296–320.

Schuldt, J.P., and N. Schwarz. 2010. "The 'organic' path to obesity? Organic claims influence calorie judgments and exercise recommendations." *Judgment and Decision Making* **5** (3): 144–150.

Sheldon, I.M. 2017. "Certification mechanisms for credence attributes of foods: Does it matter who provides diagnosis?" *Annual Review of Resource Economics* **9**(1): 33–51. https://doi.org/10.1146/annurev-resource-100516-053630.

Springmann, M., M. Clark, D. Mason-D'Croz, K. Wiebe, B.L. Bodirsky, L. Lassaletta, W. de Vries, et al. 2018. "Options for keeping the food system within environmental limits." *Nature* **562** (7728): 519–525.

Steenkamp, J.-B.E.M. 1989. *Product Quality: An Investigation into the Concept and How It Is Perceived by Consumers*. Maastricht: Van Gorcum Assen.

Steenkamp, J.-B.E.M., and H.C.M. Van Trijp. 1996. "Quality guidance: A consumer-based approach to food quality improvement using partial least squares." *European Review of Agricultural Economics* **23**(2): 195–215.

Stigler, G.J. 1961. "The economics of information." *The Journal of Political Economy* **69**(3): 213–225.

Sunstein, C.R. 2017. "On mandatory labeling, with special reference to genetically modified foods." *University of Pennsylvania Law Review* **165**(5): 1043–1095.

Sunstein, C.R. 2021. "Viewpoint: Are food labels good?" Food Policy 99: 101984.

Teisl, M.F., and B. Roe. 1998. "The economics of labeling: An overview of issues for health and environmental disclosure." *Agricultural and Resource Economics Review* **27**(2): 140–150.

Teisl, M.F., B. Roe, and R.L. Hicks. 2002. "Can eco-labels tune a market? Evidence from dolphin-safe labeling." *Journal of Environmental Economics and Management* **43**(3): 339–359.

Thøgersen, J., and K.S. Nielsen. 2016. "A better carbon footprint label." *Journal of Cleaner Production* **125**: 86–94.

Thunström, L., J. Nordström, J.F. Shogren, M. Ehmke, and K. vant Veld. 2016. "Strategic self-ignorance." *Journal of Risk and Uncertainty* **52**(2): 117–136.

Thunström, L., K. van't Veld, J.F. Shogren, and J. Nordström. 2014. "On strategic ignorance of environmental harm and social norms." *Revue d'économie Politique* **124**(2): 195.

Vaughan, A. 2012. "Tesco drops carbon-label pledge." The Guardian. https://www.theguardian.com/environment/2012/jan/30/tesco-drops-carbon-labelling.

Willet, W., et al. 2019. "Food in the anthropocene: The EAT-lancet commission on healthy diets from sustainable food systems." *The Lancet Commissions* **373**(2): 447–492.

Wynes, S., J. Zhao, and S.D. Donner. 2020. "How well do people understand the climate impact of individual actions?" *Climatic Change* **162**, 1521–1534.

Yokessa, M., and S. Marette. 2019. "A review of eco-labels and their economic impact." *International Review of Environmental and Resource Economics* **13**(1–2): 119–163.

Zago, A.M, and D. Pick. 2004. "Labeling policies in food markets: Private incentives, public intervention, and welfare effects." *Journal of Agricultural and Resource Economics* **29**(1): 150–165.

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