Applied Economic Perspectives and Policy (2017) volume 39, number 3, pp. 407–427.
doi:10.1093/aepp/ppx028
Advance Access publication on 18 August 2017.

Feature Articles

Labeling Food Processes: The Good, the Bad and the Ugly

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Submitted 1 May 2016; editorial decision 1 May 2017.

Abstract *Consumers are increasingly exposed to labels communicating specific processing aspects of food production, and recent state and federal legislation in the United States has called for making some of these labels mandatory. This article reviews the literature in this area and identifies the positive and negative aspects of labeling food processes. The good parts are that, under appropriate third-party or governmental oversight, process labels can effectively bridge the informational gap between producers and consumers, satisfy consumer demand for broader and more stringent quality assurance criteria, and ultimately create value for both consumers and producers. Despite the appeal of the "Consumer Right to Know" slogan, process labeling also can have serious unintentional consequences. The bad parts are that consumers can misinterpret these labels and thus misalign their personal preferences and their actual food purchases. The ugly parts are that these labels can stigmatize food produced with conventional processes even when there is no scientific evidence that they cause harm, or even that it is compositionally any different. Based on this review of the literature, we provide three policy recommendations: (i) mandatory labeling of food processes should occur only in situations in which the product has been scientifically demonstrated to harm human health; (ii) governments should not impose bans on process labels because this approach goes against the general desire of consumers to know about and have control over the food they are eating, and it can undermine consumer trust of the agricultural sector; and (iii) a prudent policy approach is to encourage voluntary process labeling, perhaps using smart phone technology similar to that proposed in 2016 federal legislation related to foods containing ingredients that were genetically engineered.*

Key words: Process labeling, Consumer behavior, Policy recommendations, GMO labeling.

JEL codes: D01, Q18.

The number of consumers paying close attention to the health, safety, and social impacts of food consumption has increased rapidly and steadily across all income classes, and is no longer a niche phenomenon (Deloitte Analysis 2015). The shift from traditional drivers of food choice (price, income, taste, and convenience) towards more intangible aspects of food consumption has generated a strong demand for transparency in the food system, and more information being available to the consumer at the point of purchase. Consumers are confronted with myriad food labels appearing on grocery store shelves conveying information about nutrition (e.g., ingredients, nutrition facts, serving size), product origin (e.g., country) and much more. "Process labels" describing how crops are grown, animals are raised, or ingredients are transformed are ever more common. The most common example is the organic label, yet the range of process labels is vast, including genetically engineered (GE), free range, antibiotic-free, and cage-free chicken; grass-fed or humanely-raised beef; recombinant bovine somatotropin-free milk; shade-grown or fair trade coffee, and so on. A list of prominent process labels identifying labels as being either related to a single practice or a more complex set of practices is provided in table 1.[1,2]

An inspection of the list in table 1 reveals that in many cases process labels explain what the producer *did not do*, rather than emphasizing the production process itself. This "marketing of absence" is symptomatic of a growing sense of distrust in the food supply chain (Williams and Hammitt 2001), and reflects a general disagreement among food system stakeholders about the acceptable ways of producing food. As the information landscape has grown increasingly complex, the debate over which labels should be allowed, mandated, regulated, or altogether forbidden has heated up, and it is common to see diverging opinions polarized across well-defined groups of interest. On one side of the argument, conventional commodity producers, often backed by the scientific community, fear that labeling food production technologies may unduly scare consumers and lead to declining sales of products that have not been shown scientifically to be unsafe. On the other side, value-added producers, consumer activist groups, and some retailers, such as Whole Foods, call for more transparency in defense of consumers' "right to know". Examples of such disagreements include GE foods, recombinant bovine somatotropin (rbST), fine lean textured beef (FLTB, also known as "pink slime"), and the proper use of the "natural" label.

[1] *Genetically engineered foods are referred to by many names, including genetically modified organism (GMO), biotech, bioengineered, products made with recombinant deoxyribonucleic acid (rDNA) techniques, transgenic, or products made with modern biotechnology. For instance, rbST is a genetically engineered product. For consistency, in this manuscript, we use GE foods to refer generally to food and food ingredients that were produced in this manner, unless otherwise specified.*

[2] *While many other types of food labels exist, including nutritional facts, ingredients, serving size, and product origin information, they are generally not considered in this paper.*

Table 1 Examples of Process Labeling in Food

Single Practice	Set of Practices
• Antibiotic Free	• American Humane Certified
• Cage-free Eggs	• Animal Welfare Approved
• "Contains" / "Free of" Genetically Engineered (Modified) ingredient	• Biodynamic (wine)
• Dolphin-safe Tuna	• Bird Friendly
• Extra Virgin (olive oil)	• Certified Humane
• Grass-fed cattle	• Fair Trade
• Pasture-raised Eggs	• Free Range
• Radura (irradiated)	• HACCP certified
• rbST-free Milk	• Halal
• Shade-grown Coffee	• Certified Humane
• Vine-ripened Tomatoes	• Kosher
	• Natural
	• Organic
	• Rainforest Alliance Certified
	• Salmon Safe
	• Sustainably Produced
	• UTZ certified

Consumers and producers can have very different views about the benefits and costs associated with science and technology "advances" in agriculture. This has led to a conflict between proponents and opponents of labeling. This tension is often expressed as the principles of "consumer right to know" versus "consumer need to know". The concept of asymmetric information can help explain this rise in demand for food with process labels. Food production has seen dramatic change over the past fifty years, and in most cases these changes have occurred outside of the direct purview of consumers. During this same time period, however, a number of new health and environmental concerns have risen in the public discourse that are related to the food system. These health trends and claims, however, whether accurate or not, can sow seeds of doubt in consumers' perceptions regarding the food they are eating, especially when they feel like they have lost control over the choices offered by the food system.

In situations where there is uncertainty regarding the cause of a problem, it is common that lay peoples' perceptions of the risks and the problem's origin will differ from the dominant views of the scientific community. Frewer et al. (1997) note that new technologies may be rejected if the resulting risks and benefits affect interested parties differently. If consumers perceive that producers reap all or the majority of the benefits while consumers shoulder the possible risks, there will likely be resistance toward the new technology. Information provided by experts, even from a trusted source, is short-lived (Frewer et al. 1997), and in situations when both scientific experts' opinions and more general negative unscientific information is provided to consumers, the negative information tends to dominate (Hayes, Fox, and Shogren 2002; Liaukonyte et al. 2013). Thus, when presented with a list of current health and environmental concerns and the potential links to modern agricultural procedures, it should not be surprising that some consumers are demanding more information—via labeling—about how their food is produced (Coppola and Verneau 2014). Furthermore, the fact that marketers use process labels as a way of distinguishing and creating a unique brand for their products with the goal of increasing sales and profits should not be surprising.[3]

The primary objectives of this article are to present an in-depth review of the current scientific evidence related to the effects of process labeling, and to provide constructive guidance to the debate surrounding the proper use of process labels. By summarizing research findings from economics, agricultural economics, marketing and consumer behavior, behavioral economics, sociology and cognitive science, this article seeks to systematically organize the existing evidence to generate a broad and, to the best of our ability, objective account of the advantages and disadvantages of process labels. Our policy suggestions take the form of general guidelines to help determine when the arguments in favor of labeling may outweigh those against (and vice-versa).

Process Labels: The Good

The distance between the consumer and producer in today's global food system poses obstacles for effective communication and the establishment of trust. Consumers cannot directly observe the food production process, implying they have asymmetric information relative to producers. Labels can help improve this situation and help develop trust between consumers and producers.

Product Differentiation and The Informative Role of Process Labels

When product quality and safety is uncertain, consumers can search for information they deem important. But when information about a food product is too costly or difficult to obtain, aligning food choices with individual preferences is problematic. Further complicating matters is the fact that many important food characteristics, such as taste, can be assessed only after consuming the food ("experience attributes"; Nelson 1970), and the authenticity of many claims, such as "extra virgin" olive oil, is known to producers but cannot be directly verified by consumers ("credence attributes"; Darby and Karni 1973).

It is well known to food economists that asymmetric information can cause consumer mistrust, to the point that markets may fail (as in Akerlof's (1970) celebrated lemons paper), or, if minimum quality standards are enforced, only minimum quality products are offered (Leland 1979). Process (and other types of) food labels have often been identified as a solution to the asymmetric information problem.[4] As pointed out by Caswell and Mojduszka (1996), labels can facilitate consumer choice by transforming credence and experience attributes into searchable characteristics, thereby decreasing the information gap between consumers and producers.

[3] *Process labeling has a long history. Kosher dietary laws outline various prohibitions of certain food products and food processes for Jews (Regenstein, Chaudry, and Regenstein 2003). Similarly,* halal *laws specify which foods are "lawful" for Muslims and prohibit the consumption of certain meat products produced using prohibited processes.*

[4] *There are numerous federal and state laws requiring the labeling of food products. While an in-depth discussion of these laws is beyond the scope of this article, these labeling requirements are intended to inform consumers about what they are purchasing and consuming, prevent consumer deception, assist consumers in making value comparisons between goods, and prevent injury to the public's health from the sale of misbranded foods. For a more detailed discussion of the legal background and framework of process labeling of food, see the summary in Council for Agricultural Science and Technology (2015).*

When the adoption of specific production processes increases product quality, labeling can sustain outcomes where both high- and low-quality products are offered, thereby creating new markets for differentiated products and ultimately increasing consumer choice (Zago and Pick 2004; Roe and Sheldon 2007). The majority of studies have found that consumers are willing to pay significant premiums for credence attributes that they either find desirable or wish to avoid. The organic sector, for example, has experienced continuous growth in the last two decades, even as price premiums for organic food remained high (USDA, Economic Research Service 2014). The beverage milk market, for example, features organic and rbST-free products in addition to conventional milk. Using scanner data, Bernard and Mathios (2005) found that consumers were willing to pay a premium of $0.73 per gallon for milk labeled as organic, and $0.26 per gallon for rbST-free milk. Similarly, Kanter, Messer, and Kaiser (2009) found that consumers were willing to pay a premium of $0.29 per quart for organic milk compared with conventional milk. Dhar and Foltz (2005) found substantial benefits to consumers ($2.53 billion) in terms of the "competitive" and "variety" effects of having these two products (organic and rbST-free milk) in the market. These studies suggest that consumers (i) prefer having a market that offers the choice of conventional, organic, and rbST-free milk with labels that make these milks distinguishable, and (ii) are willing to pay significant premiums for organic milk and somewhat smaller premiums for rbST-free milk compared with conventional milk.

Protection of Public Health

Process labels can be used to pursue public health objectives, as the case of trans fat labeling exemplifies well.[5] After mounting evidence that trans fats (which result from the process of hydrogenation of fatty acids) were harmful for human health, in 2006 the U.S. Food and Drug Administration (FDA) mandated the reporting of trans fats content in the Nutrition Fact Labels (U.S. Food and Drug Administration 2006). Responding to consumer concerns and media attention, producers started reformulating food products, aggressively marketing "no trans fats" alternatives (Rahlovky, Martinez, and Kuchler 2012). Even before the FDA effectively banned trans fats by no longer deeming them as "Generally Recognized As Safe" (GRAS; see U.S. Food and Drug Administration 2015), a study by the Centers for Disease Control and Prevention found a 58% reduction in trans-fatty acids blood levels between 2000 and 2009, most likely a result of trans-fat labeling (CDC 2012).

Correcting Environmental Externalities

Process labels are also useful in remediating environmental externalities associated with food production, distribution, and consumption. The idea is that if consumers are willing to pay more to promote such causes, producers will identify production practices that yield better outcomes, potentially resulting in efficiency and welfare gains. Process labels play a crucial role as

[5] *Trans fats are not a production process* per se, *but they directly result from the hydrogenation of fatty acids, a production process stabilizing oils used in food preparation to increase shelf life and improve taste/texture.*

a means to credibly certify contributions to public goods, which in turn allows sellers to charge profit-bearing premiums.

A large number of willingness to pay (WTP) studies find that consumers are often willing to pay a premium for reducing food production externalities related to the environment. For example, Blend and van Ravenswaay (1999) surveyed 972 U.S. consumers and estimated that more than 40% were willing to pay a premium of $0.40 per pound or more for eco-labeled apples. Similarly, Loureiro, McCluskey, and Mittelhammer (2002) found consumers willing to pay an approximate 5% premium for apples that were produced using certified sustainable practices. Analogous WTP premiums have been measured for fair-trade and shade-grown coffee (e.g., Messer, Kotchen, and Moore 2000; De Pelsmacker et al. 2005; Chiu et al. 2016), and labels certifying improved animal welfare practices (see Lagerkvist and Hess 2011 for a meta-analysis).

Results from stated-preferences surveys should be taken with a grain of salt since consumers notoriously tend to overstate how much they are willing to pay for food attributes (i.e., hypothetical bias, see Loomis 2011) in hypothetical scenarios, and even more when labels relate to socially-desirable outcomes (i.e., social desirability bias, see Fisher 1993 and Norwood and Lusk 2011). However, when strong consumer interest and media attention meets careful policy making, process labels can cause real, positive change. One notable example is the case of dolphin-safe labeling and a verification program orchestrated by the Inter-American Tropical Tuna commission, which was effective in reducing dolphin deaths caused by the U.S. tuna fleet from more than 100,000/year in the 1970s to less than 5,000/year in 2002 (National Research Council, 1992). Teisl, Roe, and Hicks (2002) found that, while dolphin deaths dropped over this time period, market shares of canned tuna increased as consumers felt more comfortable purchasing dolphin-friendly products.

The market for foods with environmental process labels (e.g., "green" and "eco") has experienced strong growth both in the United States and throughout the world. Currently, there are more than 450 eco-labels in nearly 200 countries related to more than twenty-five industry sectors (Ecolabel Index 2015). In addition to Organic, The Rainforest Alliance Certified logo covers a wide variety of food products produced in tropical countries, and the certification process has been adopted by large companies such as Dole, Chiquita, Heinz, Walmart, and IKEA (Vermeer, Clemen, and Michalko 2010). According to its 2015 annual report, more than 37 million metric tons in carbon emission reductions were verified by projects of the Rainforest Alliance (Rainforest Alliance 2016).

Supporting Workers in Developing Countries

The fair trade market is supported by those who volunteer to pay more for food in order to improve the living conditions of farmers in developing countries. An in-store experiment conducted by Hainmueller, Hiscox, and Sequeira (2014) using real products in a grocery store setting found that sales of two popular coffees rose by almost 10% when labeled as fair trade, and demand for fair trade coffee was less sensitive to price variations compared to a generic placebo label. The literature assessing how fair trade certification affects participating farmers is less conclusive, as self-selection bias complicates matters. Dragusanu, Giovannucci, and Nunn (2014) reviewed a large body of work in this area, and concluded that fair trade coffee is "a cup half full".[6] The program has clear shortcomings, most notably unresolved distributional/equality issues and oversupply, but in many cases fair trade farmers adopted more environmentally-friendly production practices, had improved access to credit, and received higher income.[7]

Process Labels: The Bad

The assumption that truthful labels will always benefit (or at least will not hurt) consumers may seem reasonable, but it can be unrealistic. Since consumers are free to disregard information they do not find important or relevant, one could argue that providing truthful information via labeling can only facilitate consumer choices. Indeed, this is the argument at the heart of most consumer "right to know" campaigns arguing for mandatory labeling of food attributes and production processes. Whereas process labels can transform many credence and experience attributes into searchable information, reading labels to acquire information requires cognitive effort. As argued by Jacoby, Chestnut, and Silberman (1977), "by placing information onto a package panel, we engage in printing, nothing more. The contention that this act of information provision is equivalent to communicating with the consumer represents an unverified assumption."

Information Overload and Crowding Out Effects

Consumers face hundreds of decisions each day, and food choices are often made using simple heuristic rules. Although process labels can transform credence and experience attributes into searchable information, reading labels requires cognitive effort. When consumers' interests are heterogeneous and the number of attributes and processes to potentially label is large, a key challenge is to establish how relevant the information is to the choices of most consumers. Lusk and Marette (2012) showed that if consumers' attention to information is limited, additional information can distract consumers and complicate the search process, decreasing consumer welfare. Even though a particular piece of information may be of interest to some, the addition of a label will make searching more cumbersome for others. Just as unwanted e-mails generate clutter in inboxes, "massive over-information carries a cost for the consumer, in terms of time spent looking for the necessary information, as well as boredom or impatience" (Salaün and Flores 2001). In the end, if there is too much information or if it is too difficult to interpret, it is rational for consumers to ignore it and remain uninformed (McCluskey and Swinnen 2004). In addition, research has shown that information overload decreases consumers' ability to detect and correctly identify nutritional labels (Bialkova, Grunert, and van Trijp 2013), which is obviously undesirable from a public health perspective.

For example, Vega-Zamora et al. (2014) found that Spanish consumers used the label "organic" as a broad signal of higher quality, even though

[6]This quote is taken from a reply to the article by Claar and Haight (2015), who clearly disagree.

[7]Studies have found that a relatively small percentage of the fair trade premium actually reaches the hands of the farmers. While certifications fees may be significant, not all certified coffee can be sold as fair trade because of limits in demand. Finally, benefits appear to accrue to farmers who are comparatively well-off, with minimal changes in wages for hired seasonal laborers.

these consumers were "not quite sure why." Thus, it should not be assumed that all consumers will acquire and process information in the same rational, objective way. As discussed below, in some cases labels may confound or misguide consumers and are unlikely to lead to improvements to the food and agricultural markets (Golan et al. 2001), nor will it help consumers align their food purchases to their true underlying preferences and values.

Confusion, Halo Effects, and Error

Although studies reporting positive or negative willingness to pay for labeled attributes are often cited as evidence of consumers' preference or aversion to a certain product, another line of the academic literature has demonstrated that consumers value process labels because they signal specific quality improvements (Steenkamp 1990). For example, consumers may believe that organic production is directly related to positive attributes such as increased product safety, healthiness, and pro-environment practices, even if these benefits have not been scientifically demonstrated. Therefore, consumers' response to and WTP for a label reflects both their preferences and beliefs. Whereas preferences are generally internal to an individual and more stable (Lusk, Schroeder, and Tonsor 2014), beliefs are more malleable and can be swayed by marketing and advertising, or they may simply be incorrect. For example, some consumers have a significant WTP for decreasing the distance traveled by food (Grebitus, Lusk, and Nayga 2013). The observation that some consumers value "low food miles," however, tells us little about the societal effects of a mile-labeling system. If consumers believe that low-food-miles tomatoes decrease environmental impact, but such tomatoes are grown in energy-intensive greenhouses, they may actually be paying a premium for the opposite of what they want (Costanigro, Deselnicu, and Kroll 2015).[8]

The previous example shows that consumers need to engage in inferential processing, which uses consumers' subjective beliefs to interpret the information the label contains. From a public policy standpoint, this inferential process is undesirable (Steenkamp 1990). Direct information about the relevant quality dimensions, on the other hand, does not necessitate consumer inference.

In the context of food, research has shown that certain cues or labels may be misinterpreted by consumers, and sometimes they may even induce a cognitive bias called the "halo effect." For instance, Schuldt, Muller, and Schwarz (2012) found that the label of "fair trade" made some consumers believe that the food had lower calories than it really had. For organics, Lee et al. (2013) found a similar "health halo" effect biasing downward calorie perception and even altering (positively) taste and sensory evaluations. So process labels, such as "organic" and "fair trade," will be inevitably interpreted to mean some things that the label is not necessarily designed to communicate. In contrast, nutrition labels on food provide information, such as the calorie count, that limits the need for inferential interpretation because

[8]*According to recent evidence, food miles are a rather poor indicator of environmental quality (Coley et al. 2011; Smith et al. 2015). Although transportation does generate pollutants, the biggest environmental impact occurs during the food production process, not the transportation phase (83% vs. 17%, according to Weber and Matthews [2008]).*

they directly communicate the nutritional outcomes determined by the chosen ingredients and production processes.

Elevated Food Safety Concerns by Consumers: Neophobia and Subjective Risk Perceptions

Neophobia, the aversion to new food, is engrained in human instincts and has a clear evolutionary explanation: it protects against the ingestion of potentially lethal toxins and pathogens. This is valid not only for humans, but for most species, especially the omnivores with broad and varied diets (Rozin 1976). In humans, the aversion to new foods is particularly marked for products of animal origin, perhaps because of the higher potential for these foods to be contaminated by pathogens (Pliner and Pelchat 1991). Given this aversion to new food, process labels communicating the use of a specific technology—generally foreign to consumers—will often induce an instinctive, negative reaction.

Evidence of this generic aversion to technology in food has been recorded in multiple settings, including the case of ethylene ripening (Costanigro and Lusk 2014). Ethylene, a naturally-occurring plant hormone, is often controlled during storage to slow or accelerate the fruit ripening process (Sinha 2012). This is similar to what consumers do when they put a banana in a fruit bowl to promote ripening, but a process label communicating that fruit was "ethylene ripened" induced a negative response on par with the aversion manifested toward GE products (Costanigro and Lusk 2014). Lusk and Murray (2015) reported that, when prompted in an online survey, 80% of consumers supported mandatory labeling of food containing deoxyribonucleic acid (i.e., DNA, the carrier of genetic information in living organisms). If food policy wants to completely embrace the "consumer right to know" philosophy, then it will be difficult to identify the limits of what should or should not be labeled.

Given that most food technologies are foreign to the layman, technology labels may induce consumers to seek additional information. Learning is certainly a positive outcome, but Swinnen, McCluskey, and Francken (2005) point out that non-experts receive most of their information from mass media, which is notorious for the focus on delivering "bad news" rather than "good news." Prospect theory presents abundant evidence that people weigh losses (bad news) more heavily than gains (good news; Mizerski 1982; Kahneman, Knetsch, and Thaler 1991), which explains why the media focus on sensationalizing negative stories. Unfortunately, scientific research proceeds at a much slower pace than the news cycle, so media imprinting can have a very strong effect on consumers' attitudes. Once perceptions are established, people tend to avoid or misinterpret information countering existing beliefs (Steenkamp 1990) because being proven "wrong" causes a sense of uneasiness and discomfort (i.e., cognitive dissonance, see Festinger 1962). Furthermore, scientific results often come in the form of tradeoffs, and people are prone to cherry-pick specific tidbits of information to support existing beliefs (i.e., confirmatory bias, see Poortinga and Pidgeon 2004). For example, Costanigro et al. (2014) found that administering the same scientific information about the pros and cons of local and organic production increased WTP of organics supporters, and changed nothing for the skeptics.

Even when positive information is reported alongside the negative, behavioral research has shown that negative news dominates positive news, a phenomenon referred to as "negativity bias" (Mizerski 1982; Kahneman et al. 1991). Hayes, Fox, and Shogren (2002) and Fox, Hayes, and Shogren (2002) showed that when scientific experts' assessment of a technology is presented alongside generic negative (unscientific) information, the negative information from activist groups dominates scientific results. This hiatus between popular perceptions and the scientific community is blatant for the case of GE biotechnology. Despite the declaration from the National Academy of Sciences that GE food is safe to eat (National Academy of Sciences 2016), a study by the Pew Research Center revealed that only 37% of the general public agrees; in contrast, 88% of scientists think GE foods are safe (Pew Research Center 2015).

As mentioned previously, Frewer et al. (1997) found that information provided by experts, even from a trusted source, is short-lived. When new information does become available—such as the National Academy of Sciences' declaration that GE food is not unsafe—this information may, in the short term, change very few people's assessment of the risks. A potential explanation of this response is that people are often reluctant to change their existing beliefs. When disconfirming evidence arises, people tend to avoid the information or misinterpret it in line with their existing beliefs (Steenkamp 1990), especially when the consequences are perceived as potentially catastrophic (Messer et al. 2011).

Decreased Consumer Demand for Safe Products

One approach, often used when labeling is mandatory, is to communicate the use of a process technology with a "contains" or "made with" label. Examples of these types of labels include efforts to identify products that contain GE ingredients or apples produced with organic practices. An alternative approach, which is often preferred under voluntary labeling, is to certify the non-adoption of a certain production process via a "free of" label, such as ice cream that was made with milk free of rbST. The choice between these ways of framing may seem inconsequential, but it can often be quite important. Using "contains" labels tends to induce a negative consumer reaction (in terms of decreasing WTP) that is much larger than the corresponding increase in WTP observed for "free of" labels (Hu, Adamowicz, and Veeman 2006; Liaukonyte et al. 2013; Costanigro and Lusk 2014). Thus, the result of mandated "contains" process labels is the likely dismissal of FDA-approved technologies, and ultimately a reduction in available choices.

Several studies have documented large, labeling-induced negative impacts on WTP (e.g., Hayes, Fox, and Shogren 2002; Lusk et al. 2005; Liaukonyte et al. 2013; Costanigro and Lusk 2014; Marette 2014; Liaukonyte, Streletskaya, and Kaiser 2015). For example, in a recent comprehensive study of seven ingredients or production practices (genetic engineering, irradiation, growth hormones, antibiotics, trans fat, high-fructose corn syrup, and artificial dyes), Liaukonyte et al. (2013) found that subjects' WTP was 67% lower, on average, for products carrying a "contains" label for such items compared with a control group that did not see the label. Lusk, et al. (2005) also found negative, but somewhat lower, impacts in their meta-analysis based on twenty-five studies encompassing fifty-seven food items containing GE foods in twelve different countries. These authors found that, on average, consumers' WTP for foods containing GE foods was 23% to 28% lower than their non-GE counterparts. Thus, the process labels become somewhat similar to the health warnings common to cigarettes or alcohol and support consumers' general concerns about the uncertain source of some medical and environmental problems.

Process Labels: The Ugly

Labeling Costs and the Price of Food

Process labels can impose significant costs to producers and governmental agencies. If labeling costs exceed consumers' WTP for the information, the label as a public policy fails on a benefit-cost basis. When process labels are voluntary, the issue is largely self-resolving: if certifying a certain process costs too much, consumers will not purchase the product and the label will disappear. Mandatory process labels, however, impose the need to segregate the assembly, processing, and distribution in the entire supply chain, which can be very expensive. As demand for food is generally inelastic, additional costs are often transferred in the form of higher food prices (Golan et al. 2001) charged to consumers, including those who may have no interest in the information. The distributional implications are of particular concern here, because higher food prices are particularly damaging for the poor, for whom the food budget represents a larger income share than for wealthier members of society.

The case of cage-free eggs is instructive of how an option for the rich can become a burden for the poor. A study by Chang, Lusk, and Norwood (2010) using real market transactions (scanner data) found that the average premium for cage-free eggs in the United States ranges between $1.00 (for white eggs) and $1.73 (for brown eggs) per dozen. The same study found that despite (or most likely because of) the large price premium for cage-free eggs, very few consumers are willing to pay for them when no one is looking, and 95% of the eggs sold are conventional white. However, when in 2008 Californian voters were asked whether chickens should have enough room to turn around (proposition 2), they responded with a resounding (63.5%) yes (Lusk 2010). A recent study (Malone and Lusk 2016) suggests that egg prices in California increased by an estimated $0.48 to $1.08 for a dozen eggs, with a surplus loss ranging between $400 and $850 million annually.

Stigmatization of Foods that Do Not Harm Human Health

Another potentially serious unintended consequence of process labeling is that it can unfairly stigmatize non-labeled, conventional products tested and approved by the pertinent regulatory agencies. The idea is that labeling a product as "Certified Humane" implicitly suggests that non-labeled, conventional products are produced inhumanely. Labeling some credence characteristics can send a signal to uninformed consumers that they should avoid or be worried about the overall safety of the product. For example, a consumer could be reluctant to consume products that are labeled as containing GE ingredients, not because of the objectively definable inherent risks of such ingredients, but simply because the label itself sends a warning signal about the product (Liaukonyte, Streletskaya, and Kaiser 2015).

A typical stigma response is that people do not make calculated trade-offs between benefits and risks, but instead they simply "shun" an otherwise safe product regardless of price (Messer et al. 2006; Hoffman, Fooks, and Messer 2014; Wu et al. 2015; Kecinski et al. 2016). An illustration of this phenomenon was the introduction of rbST-free milk, which carried a label that the product was "free of" rbST, a synthetically-produced version of the naturally-occurring bovine somatotropin. Kanter, Messer, and Kaiser (2009) conducted research designed to measure whether or not the introduction of rbST-free milk stigmatizes consumers against conventional milk. The authors found that just the label "rbST-free" alone had a substantial stigma effect on conventionally-produced milk, lowering participants' average WTP for conventional milk by 33% compared with subjects who did not see the rbST-free label prior to considering buying the conventional milk. Whereas 33% was the result from the average of all consumer responses, a more detailed review of the data suggested that a significant portion of this decrease came from individual consumers who refused to purchase the product regardless of price. Many other examples exist in which conventional commodities can be indirectly stigmatized by the introduction of new but similar products that carry process labels implicitly portraying the conventional technology in a negative light—for example, shade-grown coffee, dolphin-safe tuna, and free-range chicken.

Potential Reduction in Agricultural Productivity

For controversial technologies, however, the imposition of mandatory labels may induce firms to completely dismiss a technology recognized as safe but negatively perceived by consumers. One such example is the case of ionizing radiation in the United States, a technology that has been proven effective in reducing foodborne pathogen contamination, extending the shelf life of some fruits and vegetables, and controlling infestation by insect pests (General Accounting Office 2000). A large number of studies have investigated the effect of food irradiation, and the scientific consensus is that there is no significant negative health effects associated with food irradiation protocols (Diehl 1995). The World Health Organization also agrees that irradiated food presents no toxicological risk, and according to Kava (2007), U.S. regulatory agencies (FDA and USDA) approved the use of ionizing radiation in a large number of foods, including spices and dried vegetable seasoning (1983), pork (1985), fresh fruit and vegetables (1986), poultry meat (1990), ground beef (1997), shell egg (2000), sprouting seed (2000), and mollusks (2005).

While the technology is recognized as safe, radiation is a process that may change some intrinsic quality of a food (e.g., some vitamins are partially degraded), and therefore the FDA mandated the labeling of irradiated food with the distinctive Radura logo. Unsurprisingly, irradiated food faced resistance from consumers and activist movements, who are alarmed by the idea of eating food exposed to radiation. While in experimental settings scientific information about the incidence and severity of foodborne diseases and the benefits of irradiation has been found effective in persuading consumers, Fox, Hayes, and Shogren (2002) demonstrated that negative information from activist groups, even if unscientific, carries more weight in swaying consumer choices than factual, science-based information. Fearing a negative reaction from consumers, the food industry has generally shied away from the technology and substituted approaches not requiring a label, which include "natural" approaches (e.g., heat processing or freezing) but also chemical disinfection (e.g., fumigation of imported food with methyl bromide for quarantine purposes). According to a report from the General Accounting Office (General Accounting Office 2000) the most significant use of food irradiation in the United States is made by healthcare providers concerned about protecting immunosuppressed patients by foodborne illnesses.

Another example is that of GE foods. Alston and Sumner (2012) argued that mandating GE labels would have the effect of being an implicit ban on food containing ingredients from GE plants or products. The authors cited public opinions showing that, although the majority of the California public voted against mandatory labeling, 85% would refuse to buy products if they knew those products were produced with GE ingredients. Hence, mandatory labels could act as a pseudo ban on products produced with GE and other production practices not viewed positively by the public. Paradoxically, labels intended to provide consumers with more choice can result in market outcomes where the number of available choices diminishes.

The approval of voluntary labels certifying the non-use of rbST in dairy production similarly resulted in an implicit ban and the ultimate dismissal of the technology (at least for fluid milk products), even though milk from rbST-treated cows is indistinguishable from the rbST-free ones. The storyline is described by Runge and Jackson (2000): after rbST was approved for use on dairy farms by the FDA, some food retailers began carrying fluid milk products with the label "rbST free." Eventually, customers began contacting large food retailers such as Walmart, Krogers, Publix, Starbucks, and others with concerns that their milk might have growth hormones in it and be unsafe to drink. These retailers responded by notifying their fluid milk suppliers that they would no longer buy any milk products produced from cows treated with rbST. The end result is that today virtually all fluid milk sold in the United States is rbST-free.

A possibly long-term consequence of process labeling could be the curtailment of the historical steady rate of progress in food production. Some research has suggested that farm productivity growth may be in decline in the United States (Alston, Andersen, and Pardey 2015).[9] Alston and Sumner (2012) argue that mandating GE labels would have the effect of a ban on food containing ingredients from GE plants or products, and this shift could thwart the competitiveness of U.S. agriculture in the world market. A perhaps more subtle issue with labeling production processes is that, once a set of production practices are crystallized in a production protocol (e.g., organic), there is little incentive to further innovate and surpass the minimum requirements. Some authors (e.g., Teisl and Roe 1998) have argued that this mechanism may cause excess inertia and a lagged response to changes in available technology and consumer preferences. While this issue is not yet settled in the research, the potential for this to occur is certainly a concern.

[9]*While this research has shown a general decline in productivity, some have raised concerns that this analysis has failed to properly account for the quality adjustment in inputs and outputs. Consequently, this decline is really more of a reflection of the impact on research and development on inputs.*

Policy Implications and Conclusion

After enumerating the good, the bad, and the ugly of process labels, we are well-equipped to tackle the motivating question of this article: why are process labels so controversial? The core of the matter is that process labels are *cues* (Steenkamp 1990) that consumers use to *infer* unobservable quality traits (e.g., taste, healthiness, or environmental impacts). However, the outcomes the process is believed to produce are what generates consumer utility, not the processes. Thus, a truthful certification of the production process should make the outcomes searchable attributes. However, in current practice, process labels are difficult to verify and are still credence-based in nature. Process labels are prone to controversy because, to interpret them, consumers need to engage in an inferential process in which subjective perceptions and heterogeneous beliefs play a fundamental role.

An analogy from auto sales can help illustrate this phenomenon. When purchasing a car, drivers are generally concerned about fuel efficiency. Providing information about the engine size and combustion type, catalytic converters, and car weight may be helpful, but consumers will still need to form beliefs about how these factors affect fuel efficiency. From a public policy standpoint, this inferential process is undesirable. Most consumers do not have an engineering background, and labeling the engine type makes them vulnerable to the pitch of the car salesmen. In contrast, the miles per gallon sticker—or, even better, a gallon per miles sticker (Larrick and Soll 2008)—provides the necessary information most directly.

In light of this review of the literature, one policy recommendation is that governments should avoid imposing bans on companies voluntarily using process labels on their food as long as the labels are factually true. Policies that forbid voluntary labels go against the general desire of consumers to know about and have control over the food they are eating. This approach can backfire because it can undermine consumer trust in the agricultural sector. Consumers clearly are interested in knowing about their food and are willing to pay more for food that they believe matches their preferences and values (and also avoid food that does not).

If the primary objective of labeling is informing and educating consumers (Caswell and Padberg 1992), process labels are inherently second-best when compared to more direct measures of outcomes (Steenkamp 1990). Index-labels similar to the miles-per-gallon sticker have been developed and successfully used in food products. The calorie-per-serving count in the nutritional panel is perhaps the most notable example in the context of food. The Ratio of Recommended to Restricted (RRR), a composite index aggregating nutrient density in a simple score, and the NuVal®™ score recently adopted by several grocery stores are other similar approaches (Scheidt and Daniel 2004). These types of index labels do not require dismissing process information; rather, they can help document how processes affect important quality traits. For example, one may prefer the taste of fried chips over baked chips, but the calorie or RRR information helps identify important nutritional aspects within the fried versus baked heuristic rule of choice. Relying on process labels alone, on the other hand, is a *laissez faire* approach that inevitably surrenders the educational component of labeling to mass media, the colorful array of opinion providers, and even food retailers, who may not always be honest brokers of information.

Given these considerations, the criteria for mandating labeling of production processes—when they have been recognized as safe by the competent authorities—should be quite stringent. A reasonable rule of thumb would take into consideration that (i) the link between the production process and harm to human health is proven and significantly large, and (ii) it would not be safe to rely on voluntary labeling. Putting the rule to the test, it seems that mandating labels of hydrogenated fats meets both criteria, but very few other examples from table 1 do. In the case of labeling GE foods, neither criterion appears to be satisfied. A reasonable argument for mandatory labeling could be made for the use of subtherapeutic antibiotics in animal feed, as resistances developed in animal husbandry could be transferred to human pathogens (Witte 1998), but current evidence suggests that the risk is small (Phillips et al. 2004).

While not everything can or should be measured, the case for government involvement in developing comprehensive measures of the environmental impact (perhaps based on life cycle assessment— see Curran (2016)—or other scientific methods) of food seems stronger than the rationale for the federal certification of production processes, such as organics. The reason is that consumers heuristically interpret organic products as being better for the environment, but the label completely abstracts from fundamental environmental tradeoffs inherent to the chosen mode of transportation, preservation, and packaging (Tobler, Visschers, and Siegrist 2011). Government involvement, through the USDA or the FDA, would also guarantee the transparency necessary to build consumer trust and an open scientific debate over what and how to measure.[10] For instance, the U.S. Environmental Protection Agency's Energy Start program has helped consumers understand the energy efficiency of their home appliances through scientific measurement and product labeling. Once impact information is available, it is also harder to make misleading claims regarding the virtues or vices of a specific production process.

When voluntary process labels are needed because outcome measures are too complex or costly to obtain, moving away from dichotomous ("contains" or "does not contain") labels communicating the adoption of a specific production technology would provide more nuanced information for the consumers and better incentives to innovate for the firm. An example in the context of building is the Leadership in Energy and Environmental Design (LEED) certification, which has four levels: certified, silver, gold, and platinum. Establishing different levels of certification may also be useful in shifting the focus of the debate from the sanctification/desecration of a specific process to the outcomes that consumers and industry stakeholders are really trying to pursue. Labeling practices related to animal welfare or other societal impacts could be useful applications. The idea of using smartphone technology and codes to deliver information "on demand", such as Quick Response (QR) codes, is also intriguing as non-essential information is made available for the inquiring consumer without being force-fed to everyone.[11]

Third, voluntary process labeling can help consumers make informed decisions. Two conditions are required, however, to avoid causing false implications related to competing products. The first is that the labeling

[10]Indeed, the NuVal®TM has been criticized for maintaining its index formula proprietary.
[11]The use of QR codes is part of the 2016 Roberts-Stabenow bill on GE food labeling that was signed by President Obama (Revkin 2014; Keck 2015).

claims must be true and scientifically verifiable. This condition should hold for all claims related to labor practices, environmental impact, or effects on human health. The second is that the process labels claiming a product "contains" or is "free of" a certain production-related process should also include labels on the package stating the current scientific consensus regarding the importance of this attribute.[12] This would help prevent the problems of implicit deceit.

A fourth policy recommendation pertains to food retailers. If mandatory process labels are required, then food retailers may want to use additional (secondary) information with the labels to mitigate the potential negative effects of labels on the demand for their products. For instance, Liaukonyte et al. (2013) found that although the process label "contains" a certain process had a large negative effect on consumers' WTP, when the same label was combined with positive secondary information about the process, consumers' WTP was no different than that of consumers who did not see the label. Secondary information can also be important when labeling that a product is "free of" an ingredient or production practice. The implication of this research is that if mandatory labeling becomes law, food retailers should be able to mitigate some of the negative impacts of labels by promoting positive information about the ingredient or production process that is being labeled.

A final recommendation for industry is to keep in mind how consumers think and try to pair supply-side technological development with clear consumer advantages. For instance, the process label of "vine-ripened" tomatoes arose in response to perceived deteriorating taste quality of tomatoes due to production and supply chain-oriented technological development (Bruhn et al. 1991). This situation created a market opportunity because the tastier tomatoes could market this production processes. In a way, the entire organic and alternative food movement can be interpreted as a signal to the food industry that cheap and plentiful food should not come at the cost of wholesomeness, the environment, and eating quality. Science-based technological progress in agriculture, however, does not necessarily need to focus on productivity gains, and it can be redirected toward other objectives valued by consumers. Nutraceutical and functional foods represent a step in this direction, but there is a vast potential to use science and technology to produce healthy, tasty, and safe products in an environmentally-conscious way.

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[12]*While the determination of what qualifies as a "scientific consensus" for each process label would be a new challenge. This task could be assigned to appropriate expert panels organized by the FDA and/or USDA.*

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