The naturalness paradox: The impact of additive number used in food products on sales

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Abstract:

This research is built on a paradox: although a wide array of research has consistently shown that consumers prefer natural foods in nearly all circumstances, ultra-processed foods (i.e., foods containing a large number of additives) still dominate the food supply. Using three years of store-level scanner data coming from three distinct food categories (bakery, breakfast cereals, babyfood), we investigate the effect of the number of additives used in food products on sales. As a whole, we found that food additives have a positive and linear impact on sales. However, this effect is dependent on company and product characteristics: it is reversed for large and foreign firms, and the number of additives also penalizes both organic products and breakfast cereals. We end up by discussing implications for food companies and retailers.

Keywords: food naturalness, ultra-processed foods, additives, sales

1. INTRODUCTION

Although additives have been part of food preparation since ancient times to enhance preservation (Kermode, 1972), their large-scale and systematic use emerged only in the 1980s to support firms' globalization efforts (Baker et al., 2020). Indeed, additives provide a wide array of benefits to consumers by improving food nutrition properties, palatability or convenience (Knorr and Watzke, 2019). Their use is also beneficial for food companies and retailers as it allows to reduce significantly manufacturing and supply-chain costs by preventing food spoilage and prolonging shelf life (Branen et al., 2001). Consumers have never been so exposed to additives when purchasing food products. For instance, 54% of food products sold on the French market contain at least one additive and 10% use these additives extensively (more than 5 additives used in the product recipe) (Chazelas et al., 2020). In the US, the share of sales of food products containing a high number of additives has grown from 49.6% to 59.5% from 2001 to 2019 (Dunford et al., 2023). Similarly, in Norway, the highest share of consumers food expenditure is allocated to ultra-processed foods (i.e., foods made with a large number of additives) (Bjøntegaard et al., 2023). This trend is general and a significant increase in consumption of those type of foods has also been observed in many other countries, such as Brazil, Mexico, Canada, Sweden, and South Korea (Juul and Hemmingsson, 2015; Marrón-Ponce et al., 2019; Monteiro et al., 2010; Moubarac et al., 2014; Shim et al., 2021). This prevailing global trend suggests that incorporating additives in food products is a win-win strategy for food companies, retailers and consumers providing multiple advantages to each of them.

However, recent concerns have been expressed about the potential negative effect of certain additives on consumers' health (Nestle, 2022). While the majority of additives are known to be safe for consumer health when used in reasonable amount, a few of them have been associated with adverse health effects (Chazelas et al., 2020). A large number of observational studies have shown that consumption of ultra-processed foods is associated with a wide range of chronic diseases, such as cancer (Fiolet et al., 2018), diabetes (Delpino et al., 2022), cardiovascular diseases (Juul et al., 2021) and obesity (Askari et al., 2020). These adverse health effects may partly stem from their use of harmful additives and their combined effects (Monteiro et al., 2025). One could mention that the use of additives by food companies is well regulated by food regulatory authorities and, thus, that this risk is under control. Indeed, the Codex Alimentarius lists the food additives that can be used by manufacturers, and defines and updates on a regular basis their conditions of use based on scientific standards. However, there are important disparities between countries, and regulators are slow to incorporate the latest scientific knowledge about additives and their impact on human health. For instance, the U.S regulation allows in food more than 2,500 food additives (Pressman et al., 2017) whereas a less permissive E.U regulation allows only 330 (Chazelas et al., 2020).

In addition, the usual product development practices of food companies are more and more challenged by increasing consumers' demand for natural foods (Moscato and Machin, 2018). This increasingly leads food developers to remove and/or replace artificial substances from ingredient lists and to make it visible to consumers by using clean labels (Asioli et al., 2017). For example, on its website, the Nestlé group reported aiming at "*providing simple, clear information about [his] products, and removing unfamiliar ingredients from [his] recipes*".[1] Some retailers also engage in hunting down additives in their private label products; such as Carrefour which has removed recently 100 controversial substances from his own-label products[2]. This market observation is consistent with a large body of marketing research that has highlighted strong consumer interest in naturalness especially in the food domain (Meier et al., 2019). Naturalness encompasses various notions, but one of the most central for consumers is minimal processing and the presence of as few artificial ingredients as possible (Roman et al., 2017). Indeed, past research has shown that consumers exhibit higher preferences for foods free from additives (Rozin et al., 2004) or made with a few ingredients (Kim et al., 2022b).

Despite these important issues, we know little about when and how using food additives can impact actual consumers' actual purchase behavior. To date, consumer research has yielded mixed conclusions regarding the effect of additives on food choice. Previous studies have concluded that consumers hold

[1] https://www.nestle.in/csv/tastier-healthier/natural-ingredients

[2] DPEF.pdf

strong preferences for foods free from additives because of their presumed superior qualities (Rozin et al., 2012), and that natural claims (such as “all natural” or “no additives”) influence positively food evaluation and choice (André et al., 2019; Rybak et al., 2021). Based on these findings, one may conclude that, like Nestlé, food companies should seriously consider removing food additives from their recipes to match consumers’ expectations for naturalness. However, these findings come primarily from studies conducted in laboratory settings and relying on easy-to-digest information (e.g., front-of-pack labeling) or forced-exposure designs, which suggests they should be interpreted with caution. Furthermore, despite their growing use by food marketers (Asioli et al., 2017), additive-related claims are present sparingly on food packaging. Only around 14% of new products launched displayed additive or no preservative claims[3]. In the absence of such claims, the ingredient list is the only mandatory source of information that objectively allows consumers to identify ingredients used to make food products (Gomez, 2025). However, it is generally located on the back or the side of the package making additive-related information difficult to search and process (Elshiewy and Boztug, 2018), and their detection by consumers unlikely (Cheung et al., 2016). This could explain why the food supply offered by mainstream retailers in the US, Spain or France is predominantly composed of ultra-processed foods (Amaraggi et al., 2024).

In light of these conflicting empirical findings and the lack of clear theoretical direction, we will adopt an empirics-first approach (Golder et al., 2023) and provide an econometric analysis on a unique retail panel data covering sales from 2018, 2019 and 2020, and enriched with information about ingredients for three product categories (bakery, baby foods, breakfast cereals). To our knowledge, the present article is the first to examine the effects of food additive number on product sales and their complexity and is articulated around two research questions: What is the effect of additives including in food products on actual sales?; and How do product and firm characteristics moderate this effect? By examining the effect of additive number on sales, we contribute to improve knowledge about the role of additives, and by extension naturalness, naturalness on consumer behavior and identify the conditions

[3] https://www.innovamarketinsights.com/trends/global-clean-label-trends/

in which sales are impacted by the presence of additives in food products. This has important implications for food companies and retailers since many make effort to reduce the number of additives used in their processing methods (Sanchez-Siles et al., 2019) and, more broadly, for the organization of the current food system which heavily rely on additives (Baker et al., 2020). The remainder of this paper is structured as follows. Section 2 provides a review of the existing literature on the impact of additives and introduces the theoretical framework for the moderating variables we have identified. Section 3 details the data collection and the specification of our econometric model. Section 4 presents and discusses the main results of the analysis, including the direct impact of additives and the interaction effects of the moderators. Finally, Section 5 concludes the study and proposes avenues for future research and managerial implications.

2. STUDY FRAMEWORK

Main effect of food additives on sales

As stated above, our decision to adopt an empirical-first approach is motivated by the conflicting findings existing in the current literature (see Table 1). One stream of research consistently shows that consumers tend to value naturalness in most circumstances, leading them to favor natural over non-natural food products. In contrast, another, more scattered, body of research reports findings we interpret as a 'naturalness gap': while consumers report a preference for natural foods, this preference does not consistently translate into actual behavior.

Preferences for natural foods

Over the past decades, an extensive amount of research has demonstrated that consumers have strong preferences for natural products, except in some very specific cases (Li and Gal, 2024; Scott et al., 2020). When given the freedom to choose, consumers systematically opt for natural over processed foods (Rozin et al., 2004). These preferences are rooted in evolutionary mechanism that led humans to develop an innate appetite for nature and all things that are derived from nature (Wilson 1984). Due to the recent emphasis put in the media and the marketplace on naturalness, consumers increasingly categorized foods along a natural-processed dichotomy, highlighting the importance given to food composition in food choice (Rozin and Holtermann, 2021). Evidence from a six-country study indicates that naturalness is consistently defined by the absence of negative features rather than the presence of positive attributes (Rozin et al., 2012). In particular, when asked to define natural, consumers mentioned the absence of additives (chemicals, pesticides) as one of the most important feature of natural foods (Rozin et al., 2012). Indeed, additives are generally rejected by consumers no matter their roles or functions (Maruyama et al., 2021; Tarnavölgyi, 2003).

Consumers are however poorly knowledgeable about food ingredients and, consequently, do not process ingredient-related information systematically. As an illustration, presenting additives by their E-numbers instead of their chemical or common names significantly decreases perceived naturalness (Evans, 2010). In the same vein, past research has shown that a food framed to be made with few ingredients is found to be preferred to a food framed to be made with many even if the actual number of ingredients used to make it is in fact the same (Kim et al., 2022a). Easy-to-digest information such as front-of-pack labels have been shown to substantially shape consumer product evaluation and choice or purchase intentions (Berry et al., 2017; Lin and Wang, 2023). For instance, warning labels or claims emphasizing a food's natural qualities increase choice likelihood or purchase intentions compared to when such information is absent (Gomez, 2025; Rybak et al., 2024; Rybak et al., 2021). This is particularly true when health or hedonic goals are salient (André et al., 2019). This preference toward naturalness is so deep-rooted that it holds even when foods have identical chemical composition (Rozin et al., 2004), and leads to ascribe exaggerated properties to natural foods (Skubisz, 2017).

Such naturalness preference is indeed conjointly driven by instrumental and ideational motives, which make it even more influential (Rozin et al., 2004). Naturalness is often perceived by consumers as a signal that a product is healthier (Hagen, 2021) or tastier (Nadricka et al., 2020). Natural foods are also preferred because of the symbolism associated with nature, such as purity and authenticity (Rozin et al., 2012). However, we contend that these studies may overestimate this inclination for naturalness due to methodological limitations. Most have been conducted in laboratory settings, used non-consequential measures, employed research designs in which exposure to ingredient information is forced, or examined the effects of partial and uneven information, such as claims or labels, available on food products.

The naturalness gap

A preference for natural foods does not however consistently translate into actual behavior. Research conducted in real-life shopping environments or relying on consumption or supply data tend to show that consumers pay in fact little attention to ingredient information. The point is confirmed by the high and even dominant share of ultra-processed food consumption in many Western countries where ultra-processed products dominate mainstream supermarket shelves (Amaraggi et al., 2024). As shown by studies examining food consumption patterns (see Table 1), the rise in ultra-processed food sales is a hallmark of the nutrition transition that accompanies countries' economic development (Baker et al., 2020). Past research conducted in store settings has shown that consumers are poorly motivated to search for and process information about additives. For example, an observational study has found that only 13% of shoppers actually looked at additive-related information when purchasing foods (Grunert et al., 2010a). Similarly, an eye-tracking study further demonstrated that, when shopping online, one third of consumers never looked at extra information pages (containing nutrition and ingredient information) and only 3% of fixations were made specifically on the ingredient statement (Benn et al., 2015). These low figures can be explained by the fact that ingredient information is placed on the back or side of the package, which requires substantial cognitive effort to process (Miller and Cassady, 2015). When exposed ostensibly to additive information, consumers are often unable to detect their presence, except when they are explicitly instructed to focus on naturalness beforehand (Cheung et al., 2016), and such exposure does not necessarily result in lower purchase intentions (Gomez, 2025).

When unaware of additive use, consumers may often choose foods containing additives over additive-free alternatives due to their superior objective value. Additives are indeed used by food companies to meet consumers' expectations and elaborate food products more appealing, nutritious or convenient (Branen et al., 2001). For example, adding antioxidants can extend the shelf life of cereal products by up to 200%, which may meet consumers' demand for long-lasting products (Branen, 1975), using flavor additives in wine increases significantly product sensory evaluation (Saltman et al., 2017). Consumption of yogurts enriched with polyunsaturated fatty acids has been shown to significantly improve plasma lipid profiles, thereby contributing to better cardiovascular health of consumers (McCowen et al., 2010). These examples show that food additives provide tangible benefits to consumers and that, without awareness of their presence, products formulated with additives

However, consumers aware of the use of food additives can maintain their preferences for food products made with additives when the perceived value placed in the improved attributes outweighs the motivation to avoid additives in foods. This situation may be relatively common, as taste, cost, nutrition, and convenience are among the most important attributes influencing food choices (Chandon et al., 2022). For example, consumers express positive attitudes toward naturalness but rate the sensory qualities of a strawberry yogurt higher when it is made with a flavor enhancer (vs. with no flavor enhancer) (Hemmerling et al., 2016). Naturalness-related labels (i.e., organic) can even backfire in hedonic food categories (Van Doorn and Verhoef, 2011) due to the widespread belief that organic foods are healthier but less tasty (Nadricka et al., 2020). The above heterogeneous results and interpretations lead us to question the actual effect of food additives on sales and to enunciate the following research question:

RQ1: What is the effect of food additives on sales?

Table 1: Evidence of conflicting findings regarding the effect food additives on consumer food evaluation and choice

Sample of research supporting a negative effect of additive use in foods on consumer food evaluation and choice	
Berry et al. (2017)	All-natural claims influence inferences about the use of artificial ingredient and being organic which, in turn, increase purchase intentions.
Rybak et al. (2021)	Claims emphasizing the removal of artificial ingredients increase purchase decisions through naturalness evaluations and healthiness perceptions.
Chambers et al. (2018)	Additives are judged as the least natural food ingredients by the largest part of the participants.
Rozin et al. (2009)	Adding unnatural contaminants to foods drastically reduces their perceived naturalness.
Scott and Rozin (2019)	Adding a substance to a food decreases naturalness more than removing the same substance.
Aoki et al. (2010)	A ham sandwich free of nitrite sodium is more frequently chosen by participants than an alternative with nitrite sodium even when its positive effect on food safety or taste is underlined.
André et al. (2019)	Compared to science-based claims, nature-based claims (e.g., all natural) increased choice likelihood when health or hedonic goals are salient.
Siegrist et Sutterlin (2017)	Adding their E-numbers to food additives decreased their perceived naturalness.
Bearth et al. (2014)	Food additives trigger high risk perceptions and low acceptance.
Dickson-Spillman et al. (2011)	Perceived risk associated with food additives increases preferences for natural foods.
Evans et al. (2010)	Food additives (especially when expressed as E-numbers) decreased food naturalness perceptions.
Rybak et al. (2024)	A processing-related warning label improves perceived processing level, healthiness and purchase intentions of a frozen-food product.
Rozin et al. (2004)	Consumers prefer foods in their natural versions (vs. commercial) even when they have similar chemical composition.
Gomez (2025)	A processing-related warning label increases the choice of free-from additive foods over foods containing additives, compared to when the ingredient list is available.
Kim et al. (2022a)	Consumers prefer food products when they are framed as containing a few ingredients vs. many ingredients.
Rozin et al. (2012)	Food naturalness is defined by consumers across cultures in terms of absence of negative features more than in terms of presence of positive features.
Rozin et al. (2009)	The absence of additives is perceived as one of the most important features of natural foods.
Fernandes et al. (2024)	Consumers reported higher purchase intentions of natural (vs. conventional) versions of nine different food products.

Sample of research supporting a positive or neutral effect of additive use in foods on consumer evaluation and choice	
Bjøntegaard et al. (2023)	46.5% of food expenditure in Norway implies ultra-processed foods.
Marrón-Ponce et al. (2019)	Between 1984 and 2016, the share of ultra-processed foods in the total daily energy purchased grew from 10.5% to 23.1%
Shim et al. (2021)	The contribution of ultra-processed foods in energy intake increased in Korea from 23.1% (2010–2012) to 26.1% (2016–2018), and this trend is observed in all socio-economic groups.
Juul et al. (2022)	Using the 24-hour recall method, it was found that the consumption of ultra-processed foods in the U.S increased from 53.5% to 57% of total daily calories from 2001-2002 to 2017-2018.
Rauber et al. (2018)	Ultra-processed foods constitute 56.8% of the total energy intake of British consumers, significantly more than unprocessed (30.1%) and processed foods (8.8%).
Juul and Hemmingsson (2015)	In Sweden, consumption of ultra-processed foods has increased by 142% between 1960 and 2010.
Chang et al. (2025)	In China, the share of ultra-processed foods and drinks in the daily diet more than doubled between 1997 and 2011.
Steele et al. (2016)	Ultra-processed foods comprised 57.9 % of energy intake in the U.S. diet.
Madruga et al. (2023)	The share of ultra-processed foods in total energy intake remained stable from 55.3% and 56.6% between 2008/2010 and 2018/2020.
Cheung et al. (2016)	Consumers are unable to detect variation in the ingredient list except when asked to evaluate food naturalness before.
Schirmacher et al. (2023)	When information disconfirming expectations are provided, consumer are reluctant to purchase food products carrying natural.
Grunert et al. (2010b)	An observational study found that very few consumers (11%) checked the ingredient list when purchasing food.
Benn et al. (2015)	In a shopping online context, an eye-tracking study found that 3% of fixations focused specifically on the ingredient list.
Nadricka et al. (2020)	Organic labels enhance taste perceptions of healthy foods, but not those of unhealthy foods.
Van Doorn and Verhoef (2011)	Organic labels decrease willingness to pay for vice foods (vs. virtue) due to lower quality perceptions.

The moderating effects of food producer and product characteristics

The lack of clear relationship between additive-related information and food sales found in the literature may also be obscured by moderating factors. As stated above, trying to avoid additives when selecting foods requires high cognitive resources due to the location of the ingredient list on food packaging. Information accessibility is a key determinant of perceived search costs, which are known to reduce consumers' motivation to seek external information (Schmidt and Spreng, 1996). In such a context, consumers should first rely on heuristics to assess whether a food contain additives or not. Past research has shown that when information is hard to process, consumers use superficial packaging cues to evaluate product attributes (Chalamon and Nabec, 2016; Gomez, 2013). However, using product cues does not necessarily imply that consumers disregard more detailed information such as the ingredient list. Indeed, packaging cues often act as signals that help consumers decide whether to engage in more detailed information processing. For example, health cues (e.g. traffic light) encourage consumers to spend more time to scrutinize food packaging (Koenigstorfer et al., 2014) and to process more extensively nutrition information (Bix et al., 2015). Thus, consumers might still view the ingredient list when cues reflecting food naturalness are disclosed on the packaging.

In this research, we investigate cues related to company and product characteristics, taking into account hints from prior research and their availability in our dataset. First, company size may lead consumers to suspect the presence of additives. In particular, consumers hold the belief that large companies use more food additives than small ones. This lay belief may be based on two complementary preconceptions. Past research has shown that consumers tend to hold the intuition than smaller firms make more natural foods (Scekic and Krishna, 2021). This belief is rooted in the idea that larger companies are more likely to rely on modern processing to make foods due to their presumed superior R&D capabilities (Woolley et al., 2023) or that they incorporate cheaper and less natural ingredients to support mass production (Scekic and Krishna, 2021). Relatedly, the lay beliefs that large firms use more additives in their manufacturing process may be supported by the fact that it is assumed by consumers that large firms are judged as greedier than smaller firms (Arango et al., 2023) and less morally responsible (Green and Peloza, 2014). Consistently, large multinational food and beverage companies are often criticized because of their method of processing involving the use of a plethora of food additives to expand their markets and satisfy consumers' desires at the expense of their nutritional needs (Stuckler and Nestle, 2012). In line with this reasoning, mass production is associated in consumers' mind to quality deterioration, particularly healthiness and tastiness (Roininen et al., 2006).

We expect the same role for cues reflecting production location. Indeed, it is often believed that global companies are the main providers of ultra-processed foods, although this belief is inaccurate (Gibney et al., 2017). Consumers tend to link product location with naturalness. Recent research shows that natural claims trigger expectations that products carrying such claims are produced locally (Schirmacher et al., 2023). Overall, consumers tend to favor domestic products (Balabanis and Diamantopoulos, 2004) and ascribe positive qualities to local foods (Merle et al., 2016). Locally made is associated to higher freshness, healthiness, tastiness, safety and support to the local economy (Merle et al., 2016; Roininen et al., 2006). Past research has also shown that authenticity is central to the positive effect of brand localness on product sales (Hoskins et al., 2021). Conversely, foreign products are sometimes perceived as of lower quality (Elliott and Cameron, 1994) and purchases of such products are judged as riskier than those of domestic products (Baumgartner and Jolibert, 1978). Past work on country of origin effect has shown that the role of location in product quality judgment can be more nuanced and varied according to national stereotype (Verlegh and Steenkamp, 1999). In particular, country image can be associated differently with food values (Dobrenova et al., 2015; Gomez and Torelli, 2015) and may inform consumers about the potential use of food additives. For example, food products made by U.S. firms may be perceived as unhealthy due to the widespread belief that the United States is the land of junk food (Schlosser, 2012) whereas Italian firms may benefit from the positive image of the Mediterranean diet (Ingrassia et al., 2023).

Product-related cues can be also informative about additive use in foods. First, we propose that category perceived image may play a role in the relationship between food additive use and sales. Indeed, consumers believe that food categories vary in terms degree of processing. For example, Ares et al. (2016) asked participants to assign product categories to ultra-processed foods and found that they tend to place frequently these foods in categories such as processed meats, soft drinks, and snacks, and rarely in fruits, vegetables, or bread. The potential predictions regarding the role of product category in the relationship between additive information and sales can go in both directions. On one hand, attention to additive-related information may be higher in food categories with a strong natural image. This counterintuitive assumption has received empirical support in the nutrition field. Past research has shown that a FOP nutrition labeling is more impactful and that consumers tend to use more nutrition information in healthier food categories (Balasubramanian and Cole, 2002; Nikolova and Inman, 2015). This is because in healthy food categories, consumers are guided by health motivations, and therefore place greater importance on related attributes. On the other hand, consumers may be more eager to scrutinize food composition in categories where the use of additives is believed to be frequent. In such categories, additive information is judged more diagnostic, as it helps reduce the perceived risks associated with additive consumption (Bearth et al., 2014).

A similar situation may occur with organic labels. An organic label conveys an image of naturalness (Chrysochou and Grunert, 2014) and is associated with the belief that food is made without artificial substances (Schirmacher et al., 2023) or healthier (Schuldt and Schwarz, 2010). Thus, when a product belonging to a presumed natural category or displaying an organic label contains additives, it may disconfirm consumers' expectations and lead to product devaluation. For example, disclosing to consumers that a food product carrying a natural claim is not organic decreases strongly purchase intentions (Schirmacher et al., 2023). Hence, based on expectancy-disconfirmation theory (Oliver, 1977), it is probable that consumers may feel deceived when they discover additives listed in the ingredients of organic and natural foods. However, one can also predict the opposite effect for organic labels. Under heuristic processing, organic labels signal that a product contains few or no additives (Roman et al., 2017) and can therefore circumvent consumers' search for additive information in the ingredient list. Thus, due to uncertainty in theoretical direction to follow and the lack of prior research on the role of these variables in the context of food additives, we keep an open approach and pose the following research question:

RQ2: What is the effect of company size and localness, product category and organic label on the relationship between food additives and sales?

3. METHOD

Data

The article is based on the systematic integration of three distinct data sources, mixing sales, food producers and product characteristics data. Our first dataset is scanner data at the Stock Keeping Unit (SKU) level, provided by AC Nielsen and extracted from their panel Scantrack. We observe the sales between November 2018 and November 2020 as well as price, promotion and shelf-space data[4]. The data are available for products from three food categories: babyfood, bakery products, and breakfast cereals. We selected these food categories because we wanted to select food categories involving different purchase motivations and consumption habits, and with enough variability in terms of additive use (Dunford et al., 2023). These categories have also been investigated in other research contexts dealing with product claims' effects (Chandon and Cadario, 2022).

The data included all sales from retailers operating in France including the following formats: hypermarket (store surface superior to 2500 m²; 1301 stores), supermarket (store surface comprised between 400 and 2500 m²; 4260 stores), and drive (6092 stores). Ninety percent of sales from the 3311 proximity stores (store surface comprised between 100 m² and 400 m²) was also included and all sales from the hard-discounters Aldi and Netto. A methodology of crowdsourcing is used by Nielsen to collect sales from the Lidl discounter. This allows for an almost perfect coverage of total grocery sales in France. Sales were collected on a weekly basis and were aggregated per year directly by AC Nielsen before being provided to the authors. Sales data included at the SKU level sales in value, sales in volume, share of sales in promotion, averaged price and shelf space. Nielsen data included also the product name, brand and company names, segment to which the product belongs, and product weight per unit.

Based, on product names and brands, we were able to distinguish organic from non-organic products. Products containing the term organic in the product name or produced by a brand specialized in organic food were classified as organic. Based on product names and brands, we distinguished organic from non-organic products. Items containing the term organic in their name or produced by brands specialized

[4] Promotion and shelf-space related information were only available for sales occurring in hypermarkets and supermarkets.

in organic food were classified as organic. We also enriched our dataset by including Orbis data. Orbis is a large cross-country database available from Bureau van Dijk, gathering information on all types of companies that is collected from various country-specific sources, such as national registries and annual reports. It contains data related to firm size, sector, sales, performance, governance and ownership. Hence, it allows us to know if a food product is sold by an affiliate belonging to a foreign multinational, the total sales of French affiliates or the consolidated turnover of its business group.

Using EAN codes, the scanner data complemented and matched with product characteristics information by using the Open Food Facts (OFF) database. OFF is increasingly used by nutrition and marketing researchers (André et al., 2019; Chazelas et al., 2020; Menichetti et al., 2023). This crowdsourced database gathers information contained on product packages that are self-reported by consumers who belong to a pool of contributors. The data were downloaded from the website in March 2021 and were limited to the French market and the three food categories covered in this research. We were particularly interested in food product composition to identify additives but also collected some basic nutrition information (calories per 100g, fat per 100g, carbohydrates per 100g, protein per 100g, Nutriscore). A data science analyst helped us to identify and count the number of additives included in the ingredient list. Based on their e-number, the food additives were classified among 8 categories of additives authorized in Europe (antioxidants, dyes, emulsifiers, stabilizers, gelling agents, thickeners, preservatives and sweeteners) based on their e-numbers and the international numbering system for food additives[5].

[5] fao.org/fao-who-codexalimentarius/sh-proxy/fr/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FStandards%252FCXG%2B36-1989%252FCXG_036e.pdf

Table 2: Variable definitions

Explained Variables	Definition
Sales	Volume of sales per product in terms of grams, in logarithm
OFF (selection var.)	Set to 1 when additives are uploaded in OFF, 0 otherwise.
Explanatory variables: Product level variables	
Additive number	Number of additives per product
Organic claim [s]	1 for products with organic claim, 0 otherwise
Energy	Number of calories per 100g, in logarithm
Baby [s]	1 if Baby food product, 0 otherwise.
Cereals [s]	1 if cereal products, 0 otherwise
Bakery products [s]	1 if Bakery products, 0 otherwise
Explanatory variables: Retailer level variables	
Price [a s]	Price in 2018 euros per gram, in logarithm
Promotion [s]	Share of sales in promotion, in logarithm
Shelf [s]	Length of Shelf in centimeter, in logarithm
Year [s]	Year dummies that is set to one when the food is sold in the t year
Explanatory variables: Firm level variables	
Size [s]	Number of employees per year, in logarithm
Local [s]	1 of affiliated to a French Brand, 0 otherwise

All variables are observed for three years: 2020, 2021, 2022.
[a] Price in 2018 euros are delated by French price indexes from INSEE, computed at the product category level (for bakery products (Coicop 01113), Breakfast cereals (Coicop 01117) and Baby products that include baby foods (Coicop 01193).
[b] Baby food information rates are computed according to 4 sub-categories: breakfast, lunch dishes, evening meals, afternoon snack – dessert, and evening meals. The frequencies on OFF for bakery products products are computed on 6 categories: precooked, sandwich bread with crust large slice or sandwich bread with crust, toasted bread or Swedish bread or dry biscuit bread or toast or braised bread, unleavened bread or crackers or crack bread or dry bread or breadsticks and baguettes, extruded and specialties. The cereal category has no subcategories clearly identified.
[s] Variables that are in the selection equation.

The dataset construction involved a series of matching and filtering steps, resulting in a final panel used for analysis. The initial Nielsen dataset comprised 4 795 unique products observed over three years, yielding 10 335 product-year observations from over 380 food producers. Sequential matching with the Orbis database reduced this to an unbalanced panel of 5 596 observations covering 2 755 food products sold on the French market by 172 firms. The final sample required for analysis - products matched with Open Food Facts (OFF) ingredient and information on additives - is a subset of 3 342 observations across 1,582 unique products from 111 food producers.

Variables

The different variables included in our analysis are defined in Table 2. Our main dependent variable is food sales. To measure food sales, we used sales in volume in equivalent units similarly to Nikolova and Inman (2015) and Maesen et al. (2022). At product level, food sales were divided by product weight and multiplied per 100. The variable is taken in logarithm. Our core explanatory variable is food additive number. For each product, we compute the number of additives included in the ingredient list. The ingredient list is mandatory and obliges food producers to inform consumers about additives used to make the product. The quantity of additives is not reported by food companies in the ingredient list but they have to complain with the European Union regulation to respect maximal safety level fixed for each additive.

As moderating variables, we use product and firm characteristics' predictors. The company size information was provided through the ORBIS database. The number of employees was used as a proxy for company annual size similarly as in past research (Yang and Aggarwal, 2019). We use a dummy variable to indicate whether the company owning the brand is domestic or foreign based. Localness is operationalized through the location of the company's headquarters (Hoskins et al., 2021). Conversely, domestic firms are considered as local companies. Every foreign multinational in our sample produces some food products in French facilities and the reverse is true for local company, however we consider this information anecdotal, as there is no legal requirement to mention it on product packaging. We determined the variable food category based on Nielsen's market classification. We use a dummy variable to indicate if the product is labelled organic or not using the method describing above. Products were coded as 1 if organic and 0 if non-organic.

We control for different variables provided by Nielsen that may affect product sales. First, we account for some marketing variables through the average (constant) price proposed during the year, if there is a promotion or not on the food product, as well as the shelf length allocated to each product in store. The types of products observed in this research are subject to negative price elasticity; therefore, price variations are expected to affect product demand (Andreyeva et al., 2010). Furthermore, food products incorporating many additives are generally cheaper than those free from them, thereby reinforcing the importance of controlling for price effects in the analysis (Aceves-Martins et al., 2022). Past research has shown that shelf space has direct effects on sales and contribute also to moderate the effect of price (Waller et al., 2010). Sales promotion have also immediate positive effects on sales (Gupta, 1988). To finish, the nutritional profile of the product warrant consideration and was assessed with the energy level per weight since foods containing additives haves often poorer nutritional profiles and act as a potential confounding factor (Astrup et al., 2022).

Econometrics

To estimate the impact of additives on demand as well as the moderating roles of product claims and producers' features, we thus introduce the following econometric specification of demand for food products:

$$\log(Sales_{it}) = \beta_0 + \beta_1\ Additives_{it} + \beta_2\ Size_i + \beta_3\ Local_i + \beta_4\ Organic_i + \beta_5\ Baby_i + \beta_6\ Cereals_i + \sum \beta\ \ Control_{it} + \delta_t + \varepsilon_{it} \qquad (1)$$

Where i is the product i time t, the year of observation. We introduce time dummies δ_t are introduced in our model to consider annual chocks (e.g. COVID) or the fact that firms may change also recipes to adapt to the demand or to be compliant with the regulation. Bakery is taken as a control variable in the following. The model allows us to investigate the impact of additives on Sales, controlling product level variables, producer level variables and retailers' level variables. However, whereas producers are identified, retailers are not. As a result, we were not able to control retailers' fixed effects and especially chain store fixed effects. In the demand equation, prices are constant prices to cope with inflation and its influences, including potential substitution effects among products.

To answer RQ2, identifying the role of moderators, we also introduced a specification with interaction variables between the Additives variables and our variables of interest, producers' characteristics (Size, local) and product characteristics (Organic, food type): Additives x Size, Additives x Local, Additives x Organic, Additives x Baby and Additives x Cereals.

We use a standard random effects (RE) estimator for our panel data model. However, biases related to sample selection are possible, given that only certain customers upload ingredient information, which appears at the store level. The decision to upload information may be significantly influenced by both customer-specific factors (beliefs and characteristics) and retailer attributes and strategies. We address potential sample selection bias, implementing a two-step selection correction procedure proposed by Wooldridge (1995) for panel data. This method involves, first, estimating a selection equation that models the probability of uploading information. It generates the annual Inverse Mills Ratios (IMRs) that are then incorporated into our main model as additional regressors to provide a consistent correction for the selection bias. In such model, to identify properly our parameters of interest, we should introduce an exclusion restriction (Wolfolds and Siegel, 2019) that is a variable which explains the observation of additives but does not affect the sales of food products. It is difficult to identify such variable since the selection variable determinants are often similar to the determinants used in the outcome equation (Cameron and Trivedi, 2005). In the present article, we fail in identifying such variable and thus rely on the non-linearity of the inverse Mills Ratios to identify the parameter of interest in our main equation.

4. RESULTS

Descriptive statistics

Table 3 presents the descriptive statistics for the complete sample (N=5596) and the additive data sub-sample from Open Food Facts (OFF=1, 3342 observations). The overall assortment contains a significant share of premium products, as evidenced by the high proportion of organic items (35%). This clearly exceeds average market penetration[6], but this overrepresentation can be attributed to the specific food categories included in this study. High retail competition is captured by the prevalence of promotional activity (88.1% of products). Temporally, the sample is imbalanced, with 2018 contributing only 21% of the observations (since there are 2 months of observations only).

The OFF sub-sample shows distinct economic characteristics, suggesting potential self-selection effect: Products in this cohort are associated with much higher average sales (x5) with command prices approximately 33% lower, sold on larger shelves (+26%). The OFF sample also underrepresents baby foods (mean is 36.4%) in favor of cereals (mean is 33.1%). This differential data contribution suggests that consumer engagement with OFF data platforms is inversely proportional to perceived regulatory trust. Categories viewed as less transparent or more complex (cereals) may hamper data uploading, whereas those under tight oversight (e.g. baby food) likely inspire higher consumer confidence, reducing

[6] Étude de marché du bio en France

the need to share information with other parents through platforms. Analysis of food product attributes, specifically the presence and number of additives, reveals distinct formulation strategies correlated with national preferences, company size, and product category (See Table 3).

Table 3. Descriptive statistics

	All		OFF = 0		OFF = 1		
Number of obs.	5596		2254		3342		= ?
N of prod.	2755		1171		1582		
Variable	Mean	S.D.	Mean	S.D.	Mean	S.D.	
Sales (log)	9,875	2,334	8,515	2,783	10,390	2,268	***
Additive number					0,948	1,473	
Size (log)	7,052	3,313	7,458	3,362	6,778	3,251	***
Local	0,467	0,499	0,567	0,496	0,399	0,490	***
Organic	0,349	0,477	0,365	0,481	0,338	0,473	***
Baby	0,494	0,500	0,681	0,466	0,369	0,483	***
Bakery products	0,294	0,456	0,272	0,445	0,309	0,462	
Cereals	0,211	0,408	0,047	0,213	0,322	0,467	***
Price (log)	-4,572	0,652	-4,313	0,642	-4,746	0,599	***
Promo (log)	-2,613	1,481	-2,482	1,506	-2,702	1,457	***
Shelf (log)	3,006	0,463	2,869	0,428	3,099	0,463	***
Energy (log)					5,389	0,864	***
Year1	0,221	0,415	0,213	0,409	0,227	0,419	
Year2	0,393	0,488	0,389	0,488	0,396	0,489	
Year3	0,386	0,487	0,398	0,490	0,377	0,485	

Weights : inverse weighting for each product using the number of observations we have of the same product in our data base.
*** p<1% on a two tail test

The propensity for additive-free formulation is strongly and inversely influenced by the size of the supplying firm. Small and Medium-sized Enterprises (SMEs) exhibit the highest percentage of products with no additives (69%), surpassing micro-enterprises (64%) and large companies (52%). Conversely, large companies are more likely to belong to the high-additive range (4 to 9 additives), underlining a fundamental difference in formulation driven by the scale and scope of food product portfolios. An interesting counterpoint arises from geographic origin: products from foreign brands are significantly less likely to be additive-free (50%) compared to French brands or products (68%). Long-distance export transportation frequently necessitates the use of additives, such as preservatives, which could account for the observed disparities. While organic foods are less likely to contain additives, the difference between organic and non-organic foods is actually small. It suggests that producers utilize allowed organic-certified additives (See European Commission's permitted list: https://ec.europa.eu/food/food-feed-portal/screen/food-additives/search).

Table 4: Number of additives in retailed food products, repartition by main variables of interests

		Additives			
Group Variable		No additive	From 1 to 3	From 4 to 6	From 7 to 9
By Size	Micro	64.3%	31.8%	3.9%	0.0%
	SMEs	69.2%	27.2%	3.3%	0.3%
	Large	52.1%	37.9%	9.3%	0.8%
By Local Status	Foreign Brand	50.4%	37.7%	9.3%	1.0%
	Local Brand	68.1%	27.8%	4.1%	0.0%
By Organic Status	Non-Organic	56.3%	34.8%	8.2%	0.7%
	Organic	60.1%	34.5%	5.2%	0.4%
By Category	Baby	65.9%	33.3%	0.8%	0.0%
	Bread	58.3%	32.1%	8.7%	0.8%
	Cereals	48.2%	39.3%	11.7%	0.8%
Total		57.5%	34.7%	7.2%	0.6%

The table is the repartition among 1582 products.
Micro-firms are less than 20 employees, SMEs between 20 and 249 employees, Large firms are 250 employees or larger.

A food category analysis highlights clear market segmentation: Cereals stand out as the most additive-dense category, registering the lowest proportion of additive-free products (48%) and the highest use in the 4-to-6 additive range (12%). Conversely, baby foods demonstrate the highest commitment to "clean labeling," being the most consistently additive-free and organic category, with 66% containing no additives and virtually none exceeding three.

Results

Main effect of additive number on product sales

Table 5 initially examines the impact of product formulation on sales. Column 1 show a strong positive effect of additives: each additional additive is associated with an approximate 15% gain in sales (or $(e^{0.14}$-1)x100). This finding provides empirical validation for the current practice among food and beverage manufacturers, where additive use is strategically employed to enhance market performance. We also attempted to identify a potential non-linear effect, specifically an inverted U-shaped relationship, by including a squared term for the number of additives (Available on request). However, no stable or significant results were obtained, precluding the determination of an optimal or maximum number of additives for producers. The linear results strongly suggest that, from a commercial perspective, multiplying the number of additive types is favorable. Nevertheless, our data show that the maximum observed number of distinct additive types is nine. This pattern suggests a degree of self-restraint among manufacturers, likely driven by factors such as the high cost of certain additives or a rigorous cost-benefit analysis, rather than a market-imposed ceiling. Thus, producers, through market intuition if not econometric awareness, utilize additives because they demonstrably improve sales.

Regarding control variables, the effect of scale is also evident, with larger firms achieving greater sales volumes. This effect, however, exhibits diminishing returns: a 10% increase in staff size translates to only a 1.28% increase in company sales, suggesting a market barrier to extreme organizational growth within distribution. Intriguingly, the direct effect of the local variable is negative but not significantly different from 0 (Col. 1 in Table 5). A French brand or product, therefore, does not inherently drive additional sales. In the same wat sales are estimated lower for organic products compared to non-organic products, conditional on the full set of regressors, but the drop is not significant. It suggests that higher prices for organic food capture the share of variance of sales regarding organic food. The own-price elasticity is found to be around 1, exceeding some results on individual own-price elasticities for basic food products (Davies et al., 2025).

Table 5: Econometric results

	VARIABLES	(1)	(2)	(3)	(4)
β_1	Additives	0.142***	0.786***	0.126***	0.693***
		(0.032)	(0.114)	(0.030)	(0.109)
β_2	Additives X Size		-0.066***		-0.055***
			(0.010)		(0.010)
β_3	Additives X Local		0.155**		0.196***
			(0.072)		(0.073)
β_4	Additives X Organic		-0.327***		-0.339***
			(0.081)		(0.081)
β_5	Additives X Baby		-0.055		-0.068
			(0.101)		(0.091)
β_6	Additives X Cereals		-0.218***		-0.217***
			(0.077)		(0.074)
β_7	Size (log)	0.132***	0.199***	0.169	0.194
		(0.017)	(0.020)	(0.161)	(0.164)
β_8	Local	-0.060	-0.106	-0.275**	-0.355***
		(0.100)	(0.116)	(0.116)	(0.134)
β_9	Organic	-0.039	0.147	0.014	0.223*
		(0.108)	(0.123)	(0.110)	(0.124)
β_{10}	Baby	0.231	0.124	0.477***	0.378**
		(0.179)	(0.194)	(0.168)	(0.186)
β_{11}	Cereals	-0.668***	-0.492***	0.019	0.190
		(0.122)	(0.140)	(0.159)	(0.180)
β_{12}	Price (log)	-0.997***	-0.928***	-1.352	-1.249
		(0.092)	(0.093)	(0.840)	(0.830)
β_{13}	Promo	0.066**	0.069**	0.134**	0.133**
		(0.032)	(0.033)	(0.053)	(0.052)
β_{14}	Shelf (log)	1.904***	1.894***	1.586***	1.621***
		(0.145)	(0.144)	(0.201)	(0.201)
β_{15}	Energy (log)	-0.399***	-0.402***	-0.516***	-0.525***
		(0.096)	(0.097)	(0.085)	(0.087)
	Selection Equation	No	No	Yes	Yes
	Breusch and Pagan test	850.2***	832.8***		
	H_0: $\beta_2= \beta_3=\beta_4=\beta_5=\beta_6==1$		51.32***		10.52***
	H_0: IMR1=IMR2=IMR3=0			6.76***	5.82***
	R-squared	0.303	0.322	0.316	0.334

*** p<0.01, ** p<0.05, * p<0.1
5596 observations and 3342 observation selected (OFF=1) and 1582 food products.
The explained variable is the volume of sales in logarithm. Bakery is taken as a reference. Year dummies are not reported.
For the Wooldridge estimator : in columns 3 and 4, the 3 selection equations are not reported (available upon request), and. Compared to the RE panel estimator in column 1 and 2, annual Inverse Mill Ratios (IMR1, IMR2, IMR3) as well as Average control variables are introduced in pooled data. The residuals are also clustered on product identification.

Marketing variables remain also a critical predictor: promotions exert a positive but limited influence on sales: a discount over 10% of products augment sales by 0.7%. The shelf space allocation is confirmed as more pivotal with a 1% increase in display length induces a rise in sales of 1.9%. Furthermore, other product properties significantly influence sales. Specifically, high-energy content is detrimental to sales. A one percent increase in energy results in a reduction of approximately 0.5% of sales. The negative impact underscores the growing market demand for "light" or reduced-calorie products, which, ceteris paribus, generate the highest turnover for retailers.

Moderating effect of firm and product characteristics

Regarding RQ2, the company size acts as a crucial moderator. While selling additive-free products is easier for large firms, who can leverage their scale to compensate for the drastic drop in sales from additive absence, the trend reverses for additive-containing products. Column 2 of Table 5 confirms that while large firms possess a natural sales advantage, the sales dynamic created by additives increase in size is negatively impacted by the size of companies. Simply put, small firms find it easier to monetize the use of additives. The moderating effect of -0.066 in Col. 2 means that small firm (10 employees) increasing additives by one unit sees an increase in sales by 60%, a mid-sized firm (100 employees) sees 45%, while a large firm (1000 employees) registers only a 30% gain up to a null effect for firms with 100 000 employees. The effect of "local" effect on the impact of additives is found significant and positive. While local products face no significant direct sales boost, the positive role of an additive is reinforced for local brands: the impact of an additional additive is 15.5% higher for local brands compared to foreign brands. This indicates a non-price competitiveness for French products, where consumers exhibit greater tolerance for additives introduced by national companies.

The moderating role of the organic label is also significant. Regarding organic products containing (authorized) additives, the cross-effect is negative and significant. While additives remain a statistically and economically positive driver of sales in both market segments, their efficacy is reduced: the marginal effect on sales for Organic products is 41.6% lower than it is for non-Organic products (0.327 out of 0.786%) when the additives is applied to organic food products. It demonstrates a fundamental market incompatibility on markets where consumers are highly sensitive to purity and naturalness. Furthermore, selling organic products is not intrinsically lucrative, and the addition of any additive severely compounds this revenue challenge. Regarding category heterogeneity, Columns 2 in Table 5 also highlight product-specific sensitivities. A reduced number of additives in Baby food boost sales but the expected increase is not significantly higher that the increase observed in bakery products. Column 2 reveals a significant negative moderating effect for cereals: while the presence of additives is necessary, the quantity is penalized, with sales increasing by 21.8% for each additive removed, a substantial penalty only slightly less pronounced than that observed for organic products. It suggests that cereals encounter a different consumers' perception. The absence of an attenuated effect for within the baby food category, contrasting sharply with the findings for organic products and cereals, is a striking empirical observation. This divergence is primarily attributable to the unique regulatory environment and consumer trust dynamics specific to infant nutrition. Consumers are presumed to rely heavily on the strict food safety and purity standards legally enforced by state and supranational regulatory bodies (EU level).

Robustness

A significant limitation of our analysis is the absence of producer- and retailer-specific advertising budget data, which represents a potential source of omitted variable bias. We anticipate that the inclusion of proxies such as firm size and retailer promotional activity should mitigate the severity of this deficit. To address remaining concerns regarding unobserved heterogeneity, we conducted a second robustness check. Given the likelihood of within-group error correlation (i.e., common unobserved factors affecting all products from the same firm), we re-estimated the model using cluster-robust standard errors, grouped by producer identity. This procedure corrects the standard errors—which were likely downwardly biased in the initial non-clustered specification—without altering the coefficient point estimates. The econometric results confirm the presence of this bias: the interaction effects involving Cereals and Local designation lose their statistical significance, with -values rising to and respectively. However, we acknowledge that the standard errors may remain slightly underestimated due to our inability to implement multi-way clustering to account for potential unobserved retailer-specific effects. Further explorations suggests that preservatives followed by antioxidants are core drivers for market success, suggesting that some types of food additives contribute more to sales than others. Our model is based on a database significantly affected by selection bias. This common issue is potentially present, and the introduction of the solution proposed by Wooldridge corrects for a significant bias, as evidenced by the joint significance of the Mills ratios (IMR) in Table 5 (critical values in Col.2 and Col.3 are at $p<1\%$). The impact on the estimations primarily concerns especially control variables but hardly influence the significatively and magnitude of our variables of interest (β_1 to β_6) as shown in columns 3 (to be compared with column 1) and 4 (to be compared with column 2) of Table 5.

5. DISCUSSION

In recent years, food companies have focused part of their innovation efforts on reducing the use of additives in their processing methods, and retailers have increasingly expanded their assortments with products offering greater naturalness or cleaner versions of existing food products (Asioli et al., 2017). Research documenting the detrimental effects of several classes of food additives on consumer health has accelerated this naturalization of the food supply (Lalani et al., 2024; Trasande et al., 2018). However, real-world evidence suggests a more nuanced perspective on the apparent rise in consumer demand for natural foods. Indeed, foods containing a high number of additives have never been more prevalent in the food supply and, now, account for a substantial share of energy intake in both Western and emerging countries (Monteiro et al., 2025). Our research questions are motivated by this paradox and addressed through an empirics-first approach (Golder et al., 2023). To do so, we analyzed a unique dataset crossing sales and food composition data and covering three product categories over a three-year span.

Our empirical analysis offers insights, confirming or nuancing current state of knowledge. First, we do not consistently observe in our data the pattern of preferences for natural foods widely reported in past research. Indeed, one of our main findings exhibits an additive premium in which the more the product contained additives the more sales increased. We empirically show that this result hold when controlling for price level, promotion use and shelf length. Although, we found a positive expected effect of those three marketing variables on sales, additive number contributed beyond them. A second important finding is that this effect however varies depending on firm and product characteristics. Confirming the small = natural effect found in past research (Scekic and Krishna, 2021), we find that the additive premium benefit only to small companies. Indeed, for large companies, the number of additives is negatively associated to product sales. We add to past research by showing that localness act as a moderator of the relationship between additive number and sales. Like those of large companies, sales of foreign companies are penalized by the use of food additives in food formulation. Our findings are also contingent of product characteristics. Indeed, products carrying organic labels are less purchased when they contain additives, and the number of additives has a weaker effect in breakfast cereals than in baby-food and bakery categories.

5.1 Theoretical contributions

This study helps to advance our understanding of the role of food additives in product sales. It also more broadly relates to perceptions of naturalness, given the central role of additives in how consumers conceptualize food naturalness (Rozin et al., 2012). Before conducting this study, knowledge about the effect of additives on consumer behavior was inconsistent. Although past research has demonstrated that consumers generally prefer natural foods over non-natural foods, other studies have found that products made with additives are nevertheless widely purchased. First, our findings question the natural-is-better bias highlighting by past research according which a natural option is consistently preferred over a non-natural one (Meier et al., 2019). This bias has been consistently shown to influence consumer decision in the food domain (Rozin et al., 2004). Several reasons could explain why our results diverge from this literature. First, it may be due to methodological reasons. Indeed, our study differs from past research by using real-world data instead of survey or lab experiments (Li and Chapman, 2012; Rozin et al., 2004). The well-documented gap between intention and behavior observed for organic foods is therefore extended to foods that contain additives in this research (Aschemann-Witzel and Niebuhr Aagaard, 2014). Second, we examined only additives, while naturalness spans several other facets. Indeed, consumers often define food naturalness according to the level of processing it has undergone (Rozin, 2005), which may lead them to rely on organic or non-GMO labels rather than on information about additives when making decisions. Third, excepted when it is complemented by front-of-pack labels, additive-related information is not easily available on food packaging which prevent consumers from identifying food made with a minimal number of additives. Indeed, many studies have operationalized naturalness with front-of-pack natural claims (André et al., 2019; Berry et al., 2017), whereas a large part of the food supply do not carry such claims and, thus, is likely to remain undetected by consumers. Studies analyzing real-behavior data have found that consumers seldom check ingredient lists when shopping foods (Benn et al., 2015; Grunert et al., 2010c).

In addition, our analysis uncovers three moderators related to firm and product characteristics that influence the sales–additives relationship. As stated above, the presence of additives penalized before all large companies. This finding is consistent with the work of Scekic and Krishna (2021) according which consumers hold the belief that large companies use less natural methods to produce foods than small ones. This is also in line with research showing that consumers assess product quality based on company size (Woolley et al., 2023). In particular, for low-tech products such as foods, small companies are seen as having more intrinsically motivated employees and therefore taking greater care in the products they make. This could therefore lead consumers to believe that they also avoid using additives in the production process. Conversely, large companies are perceived as acting less morally and being more profit-oriented than small one which may encourage consumers to infer that they use more additives to reduce their cost production (Freund et al., 2024). Based on our analysis, localness seems to act also as a shortcut to indicate whether the product contains additives or not. Indeed, naturalness is mentally associated to freshness (Haws and Yamim, 2025), which is known to be an attribute of local foods (Baršytė et al., 2023). Recent research has shown than natural foods are expected to be grown locally (Schirmacher et al., 2023) and to contain a minimal number of additives (Bearth et al., 2014), confirming that localness is a cue that could potentially informing consumers about food composition. Our findings also shows that acceptance of food additives is lower for organic foods compared to conventional foods. These results can be explained by the expectations consumers hold about organic foods and by the fact that the use of additives in such foods may negatively disconfirm those expectations (Tangari et al., 2019). Recent research has found that disclosing that a product with natural claims is not necessarily organic decreased brand trust and purchase intentions (Schirmacher et al., 2023). Finally, we show that the effect of additive number is contingent to product category. We attribute this effect to differences in perceived naturalness across categories. Indeed, prior research has shown that consumers tend to adopt categorical thinking when making food choice (Rozin et al., 1996) and to classify foods based on their degree of processing, particularly in France where the present data were collected (Rozin and Holtermann, 2021). Thus, belonging to a natural food category may lead consumers to infer that the food is free from additive and therefore bypass the search for ingredient-related information. Confirming this assumption, a post-test with 100 French consumers confirmed that breakfast cereals (M = 3.29, SD

= 1.53) are perceived as less natural than bakery products (M = 3.68, SD = 1.46; t(99) = -2.53, p = .01) and baby foods (M = 4.01, SD = 1.58; t(99) = -3.81, p < .001). We obtained a different pattern than what nutrition-information research usually reports, where the effects of simplified front-of-pack labels tend to be weaker in food categories with low nutritional quality (Dubois et al., 2021; Nikolova and Inman, 2015). These contrasting effects can be explained by the fact that nutrition information often signals a drop in the product's sensory properties and activates the "unhealthy = tasty" intuition (Raghunathan et al., 2006) whereas additive information affects only naturalness perceptions without altering expected taste.

5.2 Implications for food companies and retailers

This research offers valuable managerial implications for food companies and retailers. Our results tend to nuance the strength of the clean label trend that has shaken up the food industry for nearly a decade (Asioli et al., 2017). Indeed, both consultancy reports and research in consumer behavior supported the view that this trend is reshaping durably the food retail landscape. Most of multinational food companies, such as Kraft Heinz[7], Mondelez[8] or Nestlé, mentioned in the introduction, include clean label reformulation to their innovation strategy by trying to elaborate foods with natural ingredient or to remove artificial additives from ingredient lists. Such shift in the product development process is significant since removing ingredients require revamping the production process and redefining the cost structure of their products. Challenging this view, our results show that, as a whole, the more products contain additives, the more their sales increase. Indeed, food additives provide many benefits that can outweigh naturalness expectations. Trade-offs with other valued attributes such as price or taste are not necessarily in favor of natural attributes (Fantechi et al., 2025). It may be advantageous for food companies to preserve key product attributes rather than compromise them for the sake of naturalness

[7] Kraft Heinz's Clean-Label Push: Strategic Implications & Market Response | Monexa

[8] Mondeléz seeks clean label, consumer friendly ingredients

by eliminating strategic additives. Product developers also need to keep in mind that food additives are also valuable to retailers, as they help prevent spoilage and extend shelf life.

Nevertheless, our findings suggest that improving product reformulation can be of interest for large, foreign or organic companies. Large or multinational companies are believed to be motivated by profit and to rely on industrial processing methods (Wilcox et al., 2024; Woolley et al., 2023), which could lead consumers to think that the use of additive serves before all the firm's self-interest. Thus, those food product developers should have this in mind while developing new recipes including too much additives. It may also be useful to inform consumers that such additives provide benefits, such as improving sensory characteristics or nutritional quality. While certain classes of additives are permitted in organic foods, product developers are advised to minimize their use in formulations, given that consumers of organic products are particularly concerned with food composition (Jolly, 1991). To mitigate this effect, retailers could also communicate to consumers that the presence of certain classes of additives in organic foods is permitted by regulation and, in some cases, necessary to guarantee food safety. More broadly, since consumers often overlook additives in certain food categories, retailers could implement specific labeling strategies to more effectively inform consumers about their presence. Given that some additives are essential to guarantee food safety and affordability, such labeling efforts could focus primarily on cosmetic or controversial additives. It also underscores the need to improve consumer knowledge about which kind of food additives should be avoided, for instance through educational programs. Our recommendations do not apply to all clean labels. Indeed, they do not consist only in cleaning the ingredient list by removing or replacing food additives. Consumers may be more responsive to other initiatives such as non-GMO or organic labels; however, these labels were not examined in this research.

5.3 Limitations and future research directions

Our research is subject to limitations. First, our results may be due to the idiosyncrasies of our research context. Indeed, we only studied three product categories and one single country, and future research could extend the generalizability of our findings across other product categories or countries. In particular, baby-food, bakery products and breakfast cereals are essentially utilitarian food categories. The removal of additives may be more problematic in hedonic food categories, where it can compromise food sensorial properties. For example, research on the impact of the NLEA on innovation strategy shows that, after its implementation, companies chose to add positive nutrients rather than remove negative ones from established brands, as this option was less detrimental to taste (Moorman, 1998). Similarly, healthy new products are valued less by stock market when they rely on ingredients removal rather than ingredient addition (Hanson and Yun, 2018). The situation may be comparable for health-oriented food products whose functional performance depends on the presence of additives. Thus, removing additives may signal that the product contains less 'science', which could harm consumer perceptions (Philipp-Muller et al., 2023).

The importance of naturalness also varies across food cultures; for example, French consumers are more likely than US consumers to categorize foods along the natural–processed dimension (Rozin and Holtermann, 2021). Thus, it would be useful to replicate our findings in other countries where the importance placed on food naturalness is lower. Further research could also explore whether the effect of additives on sales depends on their functions. This information was available in our dataset, and a complementary analysis showed that antioxidants and preservatives have a greater impact on product sales, suggesting that extending shelf life and ensuring food safety are the benefits most valued by consumers. In our research, we did not take into account the role of front-of-pack labeling such as additive disclosures. Past research has shown that the ingredient list is insufficient to influence consumer choice due to its low accessibility (Gomez, 2025). Specifically, the effect of additive number on sales could become negative when clean labels are disclosed on the packaging.

Finally, this research relies on sales data, which introduces several limitations. First, we were not able to investigate the causal mechanisms underlying the observed effects. Future studies could aim to isolate the effect of food additives and the associated consumer benefits in controlled laboratory settings. Moreover, our dataset did not include consumer characteristics, although past research has shown that sensitivity to additives varies across gender, age, education, cooking skills, income or values (Roman et al., 2017). Gaining insight into these individual differences could therefore help to better understand the nuanced effects of food additives on sales. Finally, retailer information was missing from our dataset, which prevented us from testing whether the effect of additives on sales varies across retail formats or retailer images. However, given evidence that retail outlets shape consumer perceptions of organic foods (Ellison et al., 2016), future research should examine more closely how retailer equity moderates the effect of additives on sales.

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