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Abstract: We propose an empirical study of French sales in conventional food retailing and in specialised organic stores for 2012. We examine the plant or animal origin of food products, as an indicator of the environmental and health impacts of sales, and their degree of processing, as an indicator of their health impact. The results indicate that sales of organic food products are more plant-based and less processed in specialised organic stores than in conventional retail stores, two criteria for a better health and environmental impact. In conventional stores, organic sales are more plant-based and less processed than conventional sales. Organic sales in conventional stores show some specificity, having the highest share of particular product ranges lacking a clear health or environmental impact, such as processed culinary ingredients or unprocessed or minimally processed animal products. Building a typology of buyers in conventional stores, we find that even purchases by buyers with the highest organic purchase intensity in conventional stores are less plant-based and more processed than average purchases in specialised organic stores. With less plant-based and more processed organic products sold in conventional retail stores, our results suggest that the conventionalisation of organic food retailing has negative health and environmental impacts.

Highlights:
- Specialised organic stores sell more plant-based and fewer processed products.
- Measures of both plant-based and processed products indicate that sales in specialised organic stores are more sustainable.
- In conventional stores, even purchases by buyers with a high organic purchase intensity are not as sustainable.
- In conventional stores, organic sales are more plant-based and less processed than those in conventional sales.
- Conventional stores sell more organic processed culinary ingredients, milk and eggs.

Organic food retailing and the conventionalisation debate

1. Introduction[1]

Sales of organic food products, while remaining relatively small, are increasing significantly in developed countries. In terms of sustainability, the effects of this increase are subject to debate. The contribution of this research is to analyse sales of conventional versus organic food products by retailers in France in 2012, distinguishing between sales in the major retailing networks of organic products, conventional retail stores and specialised organic stores; to our best knowledge, this approach is new in the field. Sales structures are characterised in terms of two indicators that can be identified within our data: the plant-based versus animal-based nature of products and their degree of processing.

Current food systems raise many sustainability issues. They impact air, water and soil pollution, biodiversity, ecosystems, energy use and climate change, with negative effects on human health and the environment (Foley et al., 2011; Bourguet and Guillemaud, 2016; Sutton and van Grinsven, 2011). The ongoing nutritional transition towards more animal products, vegetable oils and sugar, to the detriment of basic plant-based products, accentuates these deleterious effects (Tscharntke et al., 2012; Kearney, 2010). Worldwide, many people are overweight, some of them obese, while many others are chronically undernourished (World Health Organisation, 2015; FAO et al., 2017; Allen et al., 2011). Social and equity related dimensions are also key dimensions of a food system, pointing to both what is

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[1] Abbreviations used in this article:
- PAC (plant, animal and combined): classification of food products that separates plant-based products (or plant products, i.e., foods from plants); animal-based products (or animal products, i.e., foods from animals, including meat, fish, egg, milk, cheese, and yogurt); and combined products (foods from both plants and animals).
- NOVA (a name, not an acronym): food classification that categorises foods according to the extent and purpose of food processing (Monteiro et al., 2016).
- Conventional stores: conventional large and medium size retail stores, which sell both conventional and organic food products
- Organic stores: retail stores from the specialised organic retail channel, which sell only organic products

produced and by whom (Pretty et al., 2010). In this context, a major challenge for the coming period is the transition towards sustainable food systems, that is, food systems that ensure food security and nutrition for all now and in the future and that provide food that is healthy, of sufficient quality and quantity, affordable, safe and culturally acceptable (HLPE, 2017; Johnston et al., 2014).

Increasing awareness of issues raised by chemically intensive food systems has contributed to the sizable growth of organic farming, a production method that excludes synthetic fertilisers and pesticides. The global organic food market has nearly tripled in ten years, from $24.7 billion in 2003 to $70.1 billion in 2012 (Agence Bio, 2014). Growth in demand for organic products is driven mainly by considerations related to health, product quality and the environment (Hughner et al., 2007). However, the development of organic farming has generated controversies that revolve around two main elements.

First, some critics point to the lower yields obtained by organic farming compared with conventional farming. To produce the same quantity of a given crop, more land must be cultivated with organic farming than with conventional farming, leading some authors to conclude that organic farming may have negative impacts on biodiversity and greenhouse gas emissions, offsetting the environmental gains associated with this production method (Kirchmann and Thorvaldsson, 2000; Trewavas, 2001; Emsley, 2001; Hodgson et al., 2010; Gabriel et al., 2013; Pickett et al., 2013; see Tuck et al., 2014 for a discussion). This analysis is consistent with the analysis that a land-sparing strategy (intensive farming that leaves more room for natural areas rich in biodiversity) may encourage the conservation of more biodiversity than a land-sharing strategy (lower-yield farming that allows for a share of cultivated land between agricultural production and biodiversity but that uses more land to produce the same amount of a crop) (Green et al., 2005).

One answer to these criticisms is that conventional and organic farming cannot be compared on a production-by-production basis; instead, differences in the composition of conventional and organic diets must be taken into account to compare their effects. On the production side, organic agriculture exhibits differences in terms of crop rotations, associations between crops and livestock, rearing methods and food additives, contributing to a specific balance of different types of production and better nutritional quality (Reganold and Watcher, 2016). On the consumption side, the higher cost of organic products compared to similar conventional products can lead regular organic consumers to adjust the composition of food product bundles to control their expenditures (see Desquilbet et al., 2016, for a description of the driving mechanisms). Moreover, the motivation of organic consumers in terms of nutrition, health, environment and social criteria are likely to guide their diets. Thus, based on survey data in France, Kesse-Guyot et al. (2013) and Baudry et al. (2015) suggest that the regular consumers of organic products have a healthier diet than other consumers, including more vegetables, less meat, less alcohol and fewer sweet products.

The second element of the controversy is the tendency of organic agriculture to develop certain characteristics of the conventional food system, converse to its original intent, with potentially negative impacts on several dimensions of sustainability. This trend has been described in the academic literature as the conventionalisation of organic agriculture, introduced by Buck et al. (1997) and developed, in particular, by Guthman (2004) from the analysis of industrial organic farming in California. Buck et al. (1997) define conventionalisation as agribusiness finding ways to industrialise organic production by reconfiguring farm processes as inputs so they can be produced in the factory and by adding value and asserting control in the processing, distribution, and retailing links of the commodity chain. They find indications of the conventionalisation of organic production in California, particularly at the marketing and distribution end of the commodity chain

(regional specialisation, growth in organic imports, growth of intermediaries that coordinate organic food supply chains, brand name marketing and growth in the retailing marketplace). They also describe how conventionalisation occurs at the farm stage (notably with less stringent agronomic methods, more purchased inputs, a growth in farm size and more near-farm mechanised processing). Conventionalisation covers a wide variety of processes, and its intensity and consequences are debated; overall, however, different authors agree that it is likely to diminish the environmental and social transformative potential of organic agriculture (see the review by Constance, 2015, section 9.3).

The literature on alternative food networks shifting away from the industrialised and conventional food sector includes related questions and analyses. Wiskerke (2009) argues that different development trajectories of alternative food networks will have different levels of effectiveness and sustainability impacts. Sonnino and Marsden (2006) reflect that there are no clear boundaries between alternative and conventional food systems and that there is a need for conceptual and methodological tools to explore the nature and dynamics of the alternative sector. Watts et al. (2005) argue that weaker to stronger alternative systems of food provision exist along a spectrum, on the basis of their engagement with conventional food supply chains. They contend that organic agriculture is a weaker alternative system of food provision that is vulnerable to incorporation and subordination within conventional food supply chains because its public label emphasises the foods concerned and not the networks through which they circulate and because consumers consider its high quality to stem mainly from its taste and expected positive health impact. Forsell and Lankoski (2015) discuss the ambiguous impacts of the hybrid nature of alternative and conventional food networks on the different dimensions of environmental, economic and social sustainability. On one hand, alternative foods sold through mainstream retailers gain access to the infrastructure of the conventional network, which may provide advantages through economies of scale and by

complementing the insufficient alternative distribution channels. On the other hand, corporate food system actors may weaken practices and even governing standards by limiting or reducing the sustainability impacts of the alternative characteristics inherent to the production of these alternative foods.

Previous literature on the conventionalisation of organic farming has included empirical analyses on the sectors downstream from farming, but focused on the processing stage (Howard, 2009; Johnston et al., 2009). The increase in sales by conventional retailers is presented as a driver of the conventionalisation of organic agriculture in the academic literature but has not been the topic of dedicated empirical research. The strong penetration of conventional retailers into the organic market is also the subject of public concern and debate (Laville and Vidal, 2006; Baqué, 2012; Dion, 2013; Mercury News, 2014; Hielscher, 2017). One issue under discussion is the power of large-scale retailers in negotiations with producers and the resulting downward pressure on prices. This price pressure could encourage the industrialisation of production methods, organic monoculture, regional specialisation and imports from countries in which labour is cheap and conditions are poor for farmers, to the detriment of local employment. Discussions also cover the scope of product bundles supplied in conventional retail stores, including the gustatory quality, possible overpacking and excess advertising of these products. To date, however, no empirical research has examined sustainability indicators of the composition of organic product sales by the main players in organic retailing. This theme is the subject of the research presented here, which characterises the sales structure of food products in the two main retail channels of organic products.

This analysis is applied to the case of France in 2012. With national differences between countries, Europe is characterised by a predominance of organic sales in conventional retail stores; specialised organic retail channels also account for a relatively large share of sales, while direct sales represent a smaller share (IFOAM, 2016, Figure 7). In 2012, Europe

accounted for 44% of the world consumption of organically produced products, just behind North America. Representing 19% of sales of organic food products in the European Union that year, France was the second largest consumer country of organic products in this zone, after Germany. The share of organic products was 2.4% of food sales in France, having doubled in five years (compared with 4% in the United States) (Agence Bio, 2013). Since then, sales in France have continued to grow and accounted for nearly 3% of the country's food sales in 2015 (Agence Bio, 2016). Conventional and specialised retail channels were both well represented, with 47% of organic products sold in conventional retail stores and 36% in specialised organic stores; the remainder came from direct sales and via tradesmen and merchants (Agence Bio, 2013).

Our analysis considers sales in conventional large and medium size retail stores (here called "conventional stores"), which sell both conventional and organic food products, and in organic stores (here called "organic stores"), which sell only organic products. The novelty of this study is that it uses a database from a French channel of organic stores in addition to a database on food purchases in conventional stores. This allows us to compare sales of conventional products in conventional stores, organic products in conventional stores and organic products in organic stores. Our data limited the range of sustainability indicators that could be used in this comparison. Our indicators are the plant-based versus animal-based nature of food sales, an environmental and health indicator, and their degree of processing, a health indicator. While these two indicators are far from capturing all dimensions of sustainability, they allow us to provide new empirical insights into the differences between the sales structures of conventional and organic products at the retail stage and the specificities of organic and conventional stores for the sales of organic products. We also build a typology of buyers in conventional stores based on their organic purchase intensity (that is, the proportion of organic products in their total annual food expenditure). We use this

typology to identify the extent to which the product bundles purchased in conventional stores by buyers with the highest organic purchase intensity are similar to the average structure observed in the specialised organic channel in terms of their plant-based versus animal-based nature and their degree of processing.

This research provides some insights into both dimensions of the controversies raised by the development of organic agriculture presented above. First, our results provide information on the difference in the purchase structures of conventional and organic food products in terms of our two indicators. At a minimum, these comparisons provide information on the consumer's food environment in each retail channel, which is likely to influence consumers' purchasing decisions and food behaviours (HLPE, 2017; Glanz et al., 2005; McKinnon et al., 2008; Caspi et al., 2012; Herforth and Ahmed, 2015; Volpe et al., 2017) and therefore the sustainability of the corresponding diets in terms of our two indicators. Insofar as these differences in purchases are reflected in a difference in the composition of diets, considering these two indicators and depending on their organic product content, they also indicate the extent to which it is misleading to compare conventional and organic agriculture on a product-by-product basis, for example, by comparing specific crop yields, without accounting for the differences in the consumption patterns of regular consumers of organic products and their impact. Second, the differences in the sales structures of organic food products in conventional versus organic stores provide information on the impact of conventionalisation at the retail stage. Indeed, they indicate whether and to what extent organic sales have a less favourable structure in the conventional retail channel than in the specialised organic channel in terms of our two indicators.

Section 2 describes the two databases and the typology of buyers in conventional stores. It details why the plant-based versus animal-based nature of food products and their degree of processing are indicators of their environmental and health impacts and identifies the

limitations in our data preventing us from assessing other sustainability indicators commonly retained in studies using purchase data. Section 3 examines whether sales of organic food products are more plant-based and less processed than sales of conventional products and whether organic sales in organic stores are more plant-based and less processed than those in conventional stores. By differentiating groups of buyers in conventional stores, it then analyses whether buyers with a higher organic purchase intensity are characterised by more plant-based and less processed purchases and whether the difference between retail channels is more substantial than the difference within the conventional retail channel. We discuss these results and conclude the paper in section 4.

2. Data and Methodology

2.1. Data on food product purchases

Our study focuses on France, using year 2012 data. We used two databases. The Kantar Worldpanel database, which is classically used in scientific studies, contains detailed food purchase data from conventional stores for a sample of households. Since 2012, it also indicates whether food products are or are not organic for all food products. For the purpose of our study, we also obtained access to a database from a French channel of organic stores (selling exclusively organic products). To our knowledge, ours is the first scientific study using such data. These databases allow us to study the actual purchasing behaviour of consumers rather than relying on declarations of intent. We cannot match the data; therefore, it is not possible to study household food consumption and the way in which households shop in the two retail channels. In both databases, the data were cleaned to remove outliers.

The Kantar Worldpanel database contains data on household food purchases. For each product purchase, the database provides the price, the quantity, the retail channel and various characteristics including organic or non-organic production methods or recipe elements. We

focused on purchases made in conventional stores. Indeed, other retail channels such as organic stores, traditional trade and open-air markets were poorly represented in this database in year 2012, with a share of approximately 10% of food purchases, whereas their actual share is approximately 30% (INSEE Première, 2014). This discrepancy may have occurred either because the surveyed households primarily shopped in conventional stores or because they poorly reported their purchases outside these stores. In this database, hypermarkets were slightly under-represented, to the benefit of supermarkets and hard discounters: 46% of food purchases in conventional stores were from hypermarkets, 39% from supermarkets and 15% from hard discount stores, compared with 52%, 35% and 13%, respectively, in national statistical data (Linear, 2013). We excluded from the study the least active households, i.e., those who reported purchases for fewer than twelve weeks during the year and/or those who were inactive for more than six consecutive weeks, which was approximately one-third of the 12,345 households and 20% of the value of food purchases in the sample. We selected 7,883 households, for which the database listed more than 8 million purchases of food products. In this sample, organic products represented 1.75% of the value of purchases. This proportion is lower than the market share of organic products, which is equal to 2.4% in 2012 according to Agence Bio (2013), but is consistent with the existence of other retail channels of organic products outside of conventional retail stores (specialised channel, direct sales).[2]

The database on organic stores covers all sales of 22 stores in the specialised channel. Although these are typical stores in this channel, we did not have information on their location or their representativeness within the specialised organic channel considered. For each customer visit to a store, this database provides the date of purchase, a customer identifier, the label of each product and the purchase price. We excluded two stores from our study, one because its sales decreased sharply in August and the other because its sales

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[2] More specifically, in 2012, when the national share of organic food was 2.4%, 47% of organic food sales were made in conventional stores (which accounted for 70% of total food sales), 36% in organic stores (which, by definition, sell only organic products) and 17% in other channels.

structure was very different from that of other stores. We used data from 20 stores with more than 13 million purchases of food products.

We studied the structure of sales in these two retail channels on an annual basis. This time step avoids biases resulting from products having various storage potential and households having various purchasing frequencies.

2.2. Typology of buyers in conventional retail stores

To analyse whether buyers with a high organic purchase intensity in conventional stores had similar purchasing behaviours to buyers in organic stores, we also studied the purchasing patterns of different types of buyers within conventional stores (section 3.2). Conversely, because of the strategic nature of the specialised organic channel that provided us with data, we did not present results that differentiated buyers in this channel.

The organic purchase intensity ranged from 0% (for 519 buyers) to 61.75% of annual household expenditure in the sample, with an uneven distribution of households over this interval: half of households spent less than 0.6% on organic products, 75% of households spent less than 1.51% and only 0.25% spent more than 40%. We differentiated five types of buyers in conventional stores depending on their organic purchase intensity. The analysis of the distribution revealed organic purchase intensities above 3.42 % as extreme values.[3] The 942 corresponding households formed the group V of our typology. We divided the remaining 6,941 buyers into four classes with similar numbers of buyers in order to keep the total number of groups relatively low and with homogeneous sizes.[4] The five buyer groups are described in Table 1 below. We checked that these groups had similar numbers of active

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[3] The first three quartiles of the distribution are $q_1 = 0.235\%$, $q_2 = 0.598\%$ and $q_3 = 1.511\%$. The bound of the extreme values is defined by $q_3 + 1.5 (q_3 - q_1) = 3.42\%$.
[4] Numbers of buyers are not exactly the same across the four classes because these classes are delimited by proportions rounded to two decimal places.

purchase weeks and of total expenditure and a similar variability of their weekly expenditures.

[Insert Table 1]

2.3. Indicators: plant versus animal food products, degree of processing

The information contained in the databases limited the dimensions of sustainability that we could study. First, the organic store database did not provide exhaustive information on product weights. When available, product weights provide a common unit allowing the combination of data on nutritional contents, prices and environmental indicators calculated with lifecycle analysis in order to compare nutritional content, economic costs and diet-related environmental impacts such as greenhouse gas emissions, air acidification or freshwater eutrophication (see, e.g., Masset et al., 2014). Without such a common unit, we could not study these indicators of food sustainability. Notably, we could not assess the extent to which the composition of organic product bundles offset the additional cost of organic food – an interesting economic dimension given that the higher cost of organic products is often proposed as a hindrance to their consumption. Second, neither database contained information on the origin of products, another often debated dimension of the conventionalisation of organic agriculture (with organic product imports representing 25% of their value in France, according to Agence Bio, 2013). It was not possible either to assess the sizes of farms supplying the two retailing channels. We identified two classifications of interest that could be used on our data (Table 2).[5]

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[5] We adapted the classification of products to the specificities of each database. Kantar data for non-alcoholic food products were organised in 322 files, each file corresponding to one type of product. Of these, 301 files could be assigned directly to one of the nine groups. It was necessary to divide 21 files to account for either the plant-based or animal-based nature of the product (for example, we separated plant-based and animal-based conditioned fats) or its degree of processing (for example, we separated fruit juices from fruit nectars). For this process, we used variables providing specific information about the products. Data from organic stores contained a detailed label for each purchased product. After removing accents, punctuation, double spaces, parentheses, etc., the database contained 44,367 product labels. We compiled a list of keywords (or chain of words) to classify them within the nine groups. The classification of products was carried out by a careful

The first, which we call the plant, animal and combined (PAC) classification, separates plant-based products (or plant products, i.e., foods from plants); animal-based products (or animal products, i.e., foods from animals, including meat, fish, egg, milk, cheese, and yogurt); and combined products (foods from both plants and animals). This classification provides an indicator of the environmental impact of the purchased product bundle because the production of animal-based food requires more resources and therefore has stronger environmental impacts than the production of plant-based food, especially in terms of land use (Hallstrom et al., 2014) and carbon impact, eutrophication and acidification (Masset et al., 2014; Tilman and Clark, 2014). Thus, excluding biomass that is edible for animals but not for humans, on a world average, approximately three calories of plant-based products that could directly feed humans are instead used to feed animals to produce one calorie of edible animal products (meat, dairy products and eggs) (Paillard et al., 2014). This classification also provides a health indicator because a high level of red and processed meat consumption has negative health effects (World Cancer Research Fund/American Institute for Cancer Research, 2007; Perignon et al., 2017). This indicator is limited, however, because we cannot distinguish all red and processed meat in the database of organic stores, as detailed in the next section.

The second is the NOVA classification (NOVA is not an acronym, but the name given by the authors of this food classification) (Moubarac et al., 2014; Fardet et al., 2016; Monteiro et al., 2016). It includes the following four classes of products according to the extent and purpose of the processing they undergo: unprocessed or minimally processed foods (class 1), processed culinary ingredients (class 2), processed foods (class 3) and ultra-processed food and drink products (class 4). This classification provides a health indicator of the purchased product bundle. Indeed, contemporary diets are associated with rising rates of obesity and

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examination of the labels, and for many of them, an online check of the corresponding product and its ingredients. A total of 6,835 keywords were required to rank all labels in the nine groups, and the validity of the resulting ranking was thoroughly verified.

chronic diseases, and diets rich in ultra-processed products are associated with a higher risk of obesity (Louzada et al., 2015; Canella et al., 2014), metabolic syndrome (Tavares et al., 2012) and dyslipidaemia (Rauber et al., 2015). NOVA classes 1 and 4 are the most determinant in terms of expected health outcome, as evidenced by the recommendations to "*make unprocessed or minimally processed foods the basis of your diet*" and "*avoid ultra-processed products*". NOVA classes 2 and 3 are less decisive in terms of expected health outcome, with less stringent recommendations to "*use processed culinary ingredients in small amounts for seasoning and cooking foods and to create culinary preparations*" and to "*limit the use of processed foods, consuming them in small amounts as components of culinary preparations or as part of meals based on natural or minimally processed foods*" (Monteiro et al., 2016).

[Insert Table 2]

For each classification and for each retail channel, the sales structure was defined as the percentages of sales in each class. The data used in our study did not allow an assessment of the overall food consumption of buyers. Because we did not have product weights in the specialised organic channel, we could not assess the extent to which our comparison of sales structures in euros reflected a comparison in quantities, which is a limit to our analysis.

3. Results

3.1. Sales structure in both retail channels

We compared the structures of conventional sales in conventional stores, organic sales in conventional stores and organic sales in organic stores according to the NOVA and PAC classifications and their combination.[6]

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[6] We did not test whether the proportions in each classification were different between these three categories of sales because existing tests are based on individuals and test proportions at the individual level. This is the case, for example, for tests based on compositional data that analyse

The comparison of the plant-based, animal-based and combined nature of sales (PAC classification) is depicted in Figure 1. The results show a clear ranking: organic stores had the best sales structure in terms of the largest share of plant products and the smallest share of animal and combined products, followed by organic products in conventional stores and then conventional products in conventional stores. The differences were very important, with organic stores having a twice higher share of plant products and almost a twice lower share of animal products compared with conventional sales in conventional stores.

[Insert Figure 1]

Results were less clear-cut for the NOVA classification because for two-thirds of meat sold in the specialised organic channel (representing 6.3% of total sales in this channel), product labels were not sufficiently precise to match them with the NOVA classification. Some results depended on the classification of this meat into classes 1, 3 and 4 of the NOVA classification (class 2 contains no meat), as presented in Figure 2.

Conventional sales in conventional stores had the worst sales structure in terms of the lowest share of unprocessed or minimally processed foods and the highest share of ultra-processed foods, the two NOVA classes with a clear health implication. The unclassified meat in organic stores prevented a definite comparison of organic sales in conventional versus organic stores according to these classes. As long as the allocation of this unclassified meat was similar enough to the allocation of classified meat in this channel (with 53% in class 1 and 20% in class 4), we can conjecture that organic stores again had the best sales structure (highest share of unprocessed or minimally processed foods and lowest share of ultra-processed foods), while the sales structure of organic products in conventional stores

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proportion vectors per individual. Here, we are interested in comparing global sales structures for the three categories of sales. These global structures are weighted averages of expenses by various customers with possibly very heterogeneous purchasing behaviours. We do not think that there would be any reason why, for example, proportions of plant product purchases at the individual level should be the same for organic products purchased in conventional stores and those purchased in organic stores, and we are not interested in a comparison of the individual structures of shopping carts.

was intermediate, between that of conventional products in conventional stores and that of organic products in organic stores, according to these classes. Organic sales in conventional stores showed a clear specificity, with the highest share of processed culinary ingredients and the lowest share of processed animal products. This implies that in conventional stores, consumers tended to purchase some specific organic product ranges that were not characterised by a clear health implication.

[Insert Figure 2]

The PAC-NOVA cross-classification, presented in Figure 3, allowed a more detailed analysis of the sales structures. It notably showed that organic sales in conventional stores were characterised by the highest share of both plant and animal processed culinary ingredients (classes 2p and 2a) and the lowest share of processed animal products (class 3a). Although we cannot detail sales by product families, as they are of a strategic nature for the specialised organic channel that provided us with data, we can illustrate the specificity of organic sales in conventional stores in the case of eggs and milk (mainly category 1a, except for a small proportion of flavoured milk in category 4a). Eggs and milk represented respectively 1.1% and 2.3% of conventional sales in conventional stores; 7.7% and 9.0% of organic sales in conventional stores; and 1.2% and 1.4% of sales in organic stores. These shares show that the specificity of organic sales in conventional stores was even higher for these products than for the NOVA-PAC classes of Table 4, with a share six times higher for eggs (7.7%) and nearly four times higher for milk (9.0%) compared to the two other types of sales.

[Insert Figure 3]

3.2. Sales structure in conventional stores according to the typology of the buyers

We then analysed product bundles aggregating conventional and organic purchases bought by different types of buyers in conventional stores. We examined the extent to which the purchase structure in conventional stores varied depending on the type of buyer in that retail channel and how it differed from the sales structure in organic stores (Figures 4 and 5).

The difference between retail channels was more substantial than the difference within the conventional retail channel for each of the PAC or NOVA classes except for NOVA class 2 (processed culinary ingredients). Buyers with the highest organic purchase intensity in conventional stores (group V) had the best purchase structure among the five buyer groups in conventional stores in terms of the highest share of plant products and the lowest share of animal and combined products, as well as in terms of the highest share of unprocessed or minimally processed food (along with buyer group IV) and the lowest share of ultra-processed foods. However, they had a much lower share of plant products and a much higher share of animal and combined products than reflected by sales in organic stores. They also had a lower share of unprocessed or minimally processed products than seen in the specialised organic channel and a higher share of processed and ultra-processed foods, regardless of the distribution of unclassified meat. Therefore, the structure of food purchases was better for organic stores than for the best category of buyers in conventional stores, that is, those with the highest organic purchase intensity, for both our food classifications.

[Insert Figures 4 and 5]

4. Discussion and conclusion

Based on our study, in France in 2012, sales of organic food products were more plant-based and less processed than sales of conventional products, two indicators of better sustainability. In addition, organic sales in organic stores were more plant-based and less processed than

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those in conventional stores according to the same criteria, which provides an original contribution to analysis of the conventionalisation of organic farming. Our data suggest a detrimental impact of the conventionalisation of organic retailing in France, in that sales of organic products in conventional stores (representing almost half of organic food sales) had a worse structure than sales in organic stores (representing approximately a third of organic food sales) in terms of our two indicators. Our results can also be read as showing the positive effect of the "organicisation" of conventional stores: their more plant-based and less processed organic sales make their overall sales better in terms of our two indicators. However, this organicisation of conventional stores remains limited, as organic sales represent less than 2% of their overall sales.

The differences in sales structures were particularly important in the case of the plant-based or animal-based nature of products. Regarding the extent to which products were processed, the interpretation of results was based on assumptions concerning the classification of certain meat sold in the specialised organic channel; however, differences in sales structure remained significant under realistic assumptions regarding the classification of these meat sales. Given the importance of the differences in sales structures, it seems reasonable to consider that they also reflect differences in structure in terms of quantities, not merely differences in relative prices between channels.

The drivers of these differences in sales structures, which extend beyond the scope of our study, may be related to the organisation of the supply channels of retailers, the development of processing structures for organic products, the policy of these retailers (in particular, the specialised organic channel considered in this study has a target of healthy and local supply and responsible consumption), the characteristics and preferences of consumers, or the product prices. It is not possible to determine whether the differences between conventional and organic sales reflect differences in consumption patterns or whether customers buy

elsewhere what they do not buy in a given channel. Our findings are consistent with the more sustainable eating behaviours among regular consumers of organic products in the French Nutrinet-Santé survey (Kesse-Guyot et al., 2013; Baudry et al., 2015). This tends to corroborate that our result showing differences in sales structures between organic and conventional channels does reflect differences in consumption patterns and therefore reinforces the view that conventional and organic agriculture cannot be compared on a production-by-production basis. Moreover, these differences in sales structures imply that buyers are faced with a different food environment depending on the retail channel in which they make their purchases. As discussed in the literature on food environments inside stores, food availability, shelf organisation, promotional activity and packaging can affect consumers' purchasing decisions in stores and their diets, and the presence of a healthy food choice may positively affect eating behaviours (Caldwell et al., 2008; Chapman et al., 2006). Thus, the healthier food environment in organic stores noted in our results could help improve the food choices of customers in this channel.

Organic sales in conventional stores presented specificities in relation to both conventional sales in conventional stores and organic sales in the specialised organic channel: more culinary plant-based and animal-based ingredients, more unprocessed or minimally processed animal products, and fewer processed animal products. This finding suggests that the sales structure of organic products in conventional retail stores is very specific, as illustrated by the much larger shares of eggs and milk in these sales.

By differentiating groups of buyers in conventional stores based on their organic purchase intensity, the results showed a (weak) trend towards more plant-based and less processed purchases for buyers characterised by a higher organic purchase intensity. However, the difference between the purchase structure of buyers with the highest organic purchase intensity in conventional stores and the average sales structure in the specialised organic

channel was much more substantial. This result emphasises the singularity of the specialised organic channel in terms of our two indicators.

Our results showing a higher proportion of plant-based and unprocessed or minimally processed food products in organic stores are consistent with the policy of French private organic standards (Nature et Progrès, Demeter, Bio Coherence, etc.), which sell their products almost exclusively in organic stores or directly to consumers and not through conventional stores (Poméon et al., 2015). Compared with the European standard, their specifications impose additional sustainability requirements in terms of environmental impacts, farm autonomy and local origin of products.

Several authors note that a possible way to counter the negative impacts of the conventionalisation of organic agriculture would be to strengthen regulations on organic standards (e.g., Guthman, 2004; De Wit and Verhoog, 2007; Darnhofer et al., 2010). In our case, it would be possible to strengthen organic specifications at the processing stage in order to forbid ultra-processed organic foods, or at least the most detrimental additives, cracked ingredients and processing methods used to produce ultra-processed food. Another – and less radical – way to affect the undesirable effect of organic conventionalisation observed in our data would be to increase public knowledge about the differential health and environmental impacts of different organic products and about differences in the structure of organic sales for different retail channels. One possible step in this direction could be to associate official communication on the organic standard with recommendations on diet composition. To date, on the contrary, the French organic action plan devotes some resources to communication encouraging organic food consumption in general, without mentioning that the impacts of organic food purchase may depend on the characteristics of the purchased products, which vary across retail channels (MAAF, 2013).

Finally, an interesting way to extend this study would be to gather data on food ingredients to compare the composition of organic and conventional processed products and to study the extent to which the compositions of organic products vary depending on the retail channel. Another interesting track would be to analyse the existence and importance of off-season sales for conventional versus organic fruits and vegetables, taking into account the retail channel.

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Table 1: Typology of buyers in conventional stores

Group of buyers	I	II	III	IV	V
Organic purchase intensity	[0%; 0.20%[	[0.2%; 0.49%[	[0.49%; 1.05%[	[1.05%; 3.42%[	[3.42%; 61.75%]
Number of buyers	1749	1709	1752	1731	942

Table 2: Classification of food products

| PAC	NOVA	Products
p	1	Fresh, frozen and dried fruits; fresh, dried, germinated, frozen and lyophilised vegetables; fresh peas, fruit juices, compotes without added sugar, puree, rice, semolina, polenta, flour, pasta, muesli without added sugar, raw potatoes, pepper, spices, herbs, non-lyophilised coffee, chicory and roasted cereals, teas and herbal teas
	2	Mustard, vinegar, soy sauce, pastry aids, salt, oil, sugar and sweet products, honey
	3	Canned vegetables and legumes, olives, frozen soups, tomato coulis, pre-packaged bread, cooked potatoes, compotes, frozen ready-to-eat vegetables, unfrozen and undehydrated soups, fries, salted fruits, pickles, vinaigrette dressings
	4	Plant substitutes for dairy products, crispbread, pastry, jams, sodas, energy drinks, syrups, non-alcoholic beers, fruit nectars, other prepared meals containing no animal products, lyophilised coffee, chicory and roasted cereals
a	1	Unprocessed or minimally processed meat, eggs, fresh or frozen fish, crustaceans, unflavoured animal milk, natural yogurt, margarine
	2	Butter, cream, duck fat
	3	Ham, bacon; salted, minced, candied or smoked meat; smoked, salted or marinated fish; cheeses, unpasteurised fresh cheeses
	4	Sausages, pâté, rillettes, foie gras, breaded poultry, other charcuterie, animal milk, yogurt and flavoured white cheese
c	4	Sweetened biscuits and breakfast cereals, chocolate spread, chocolate powder, ice cream, sorbets, prepared meals containing animal products (meat, fish, egg and/or dairy products), other salted aperitif products, sauces, baby foods

Figure 1: Sales structure, PAC classification
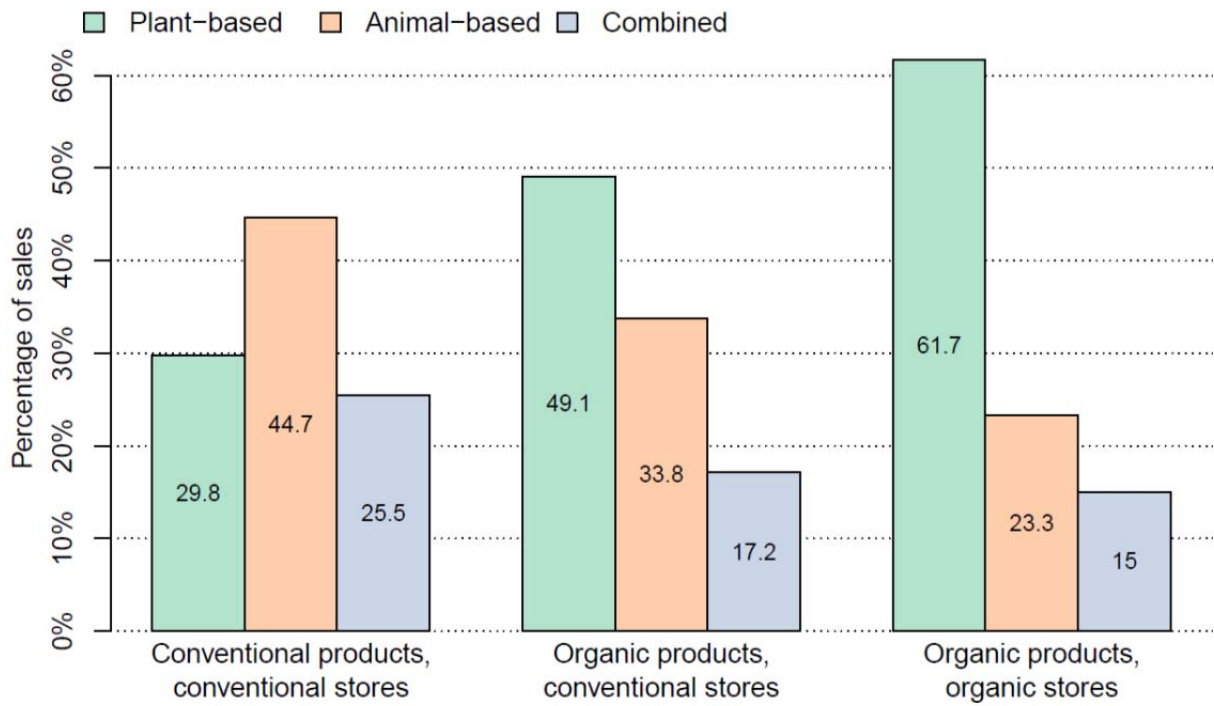
Note: this figure indicates that 29.8% of conventional sales in conventional stores are plant-based, 44.7% are animal-based, and 25.5% consist of combined products, with 29.8% + 44.7% + 25.5% = 100%; it uses the same structure to depict the distribution of organic sales in conventional stores and organic sales in organic stores.
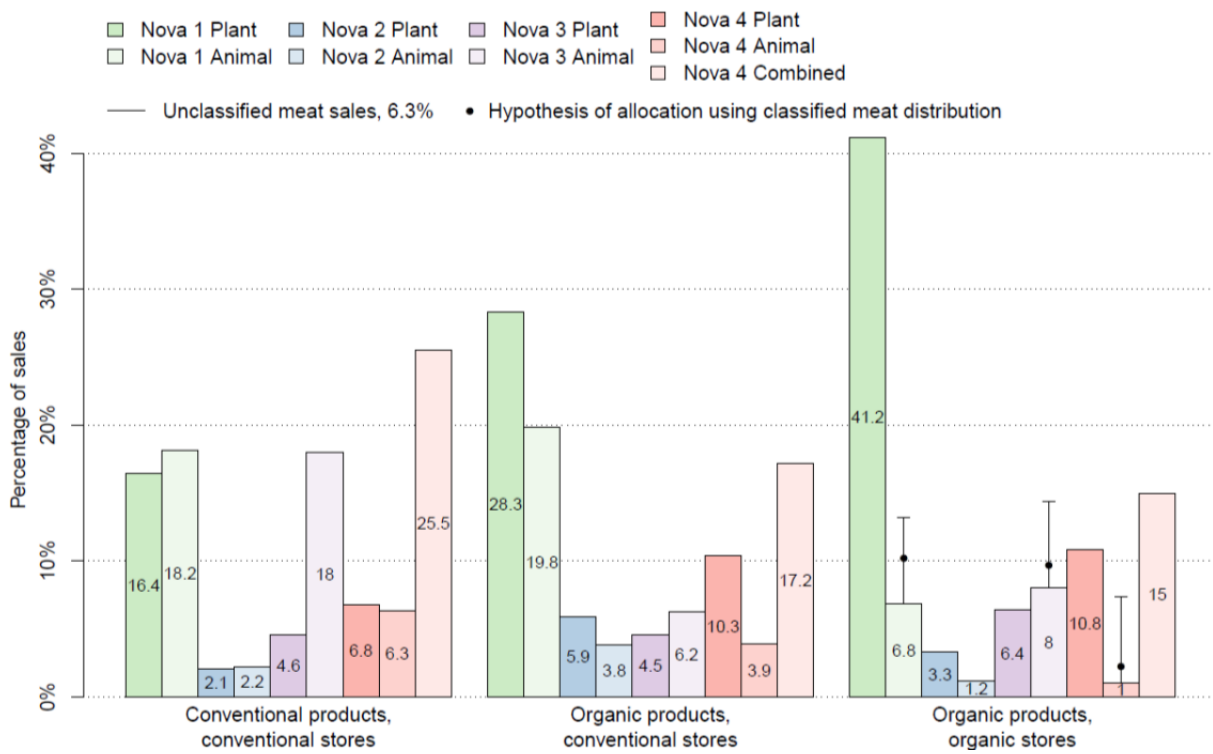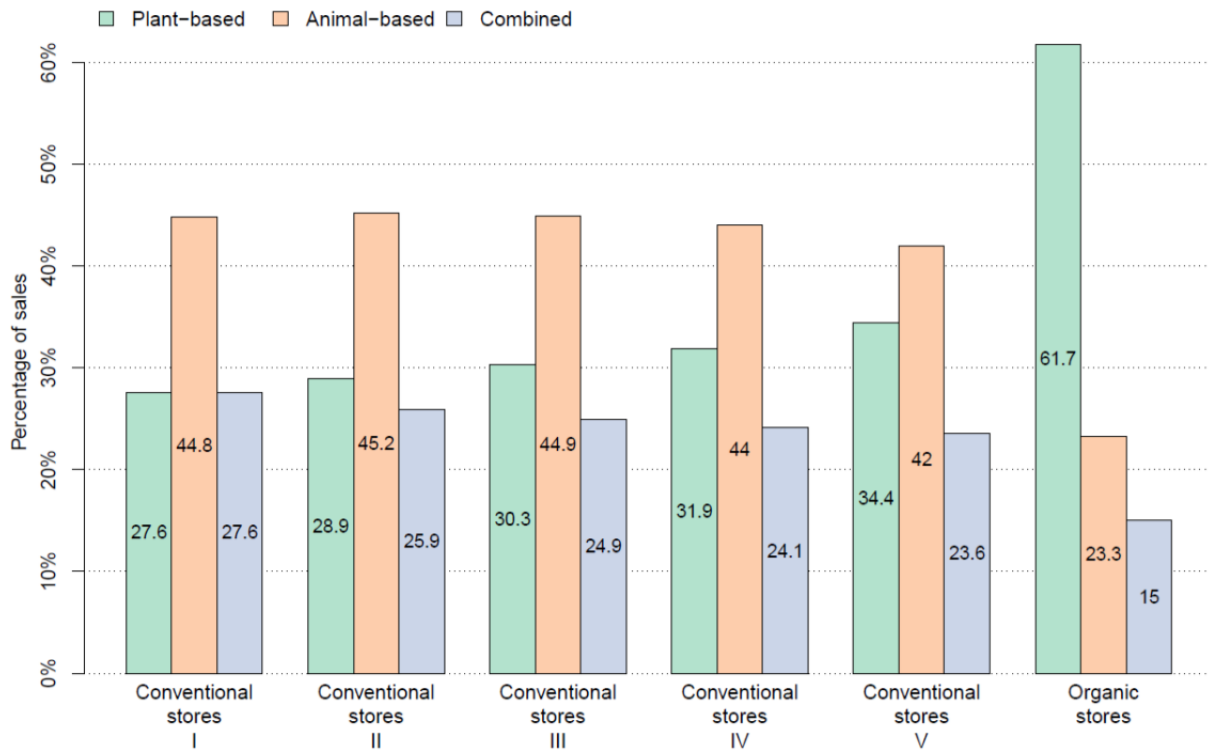
Figure 2: Sales structure, NOVA classification
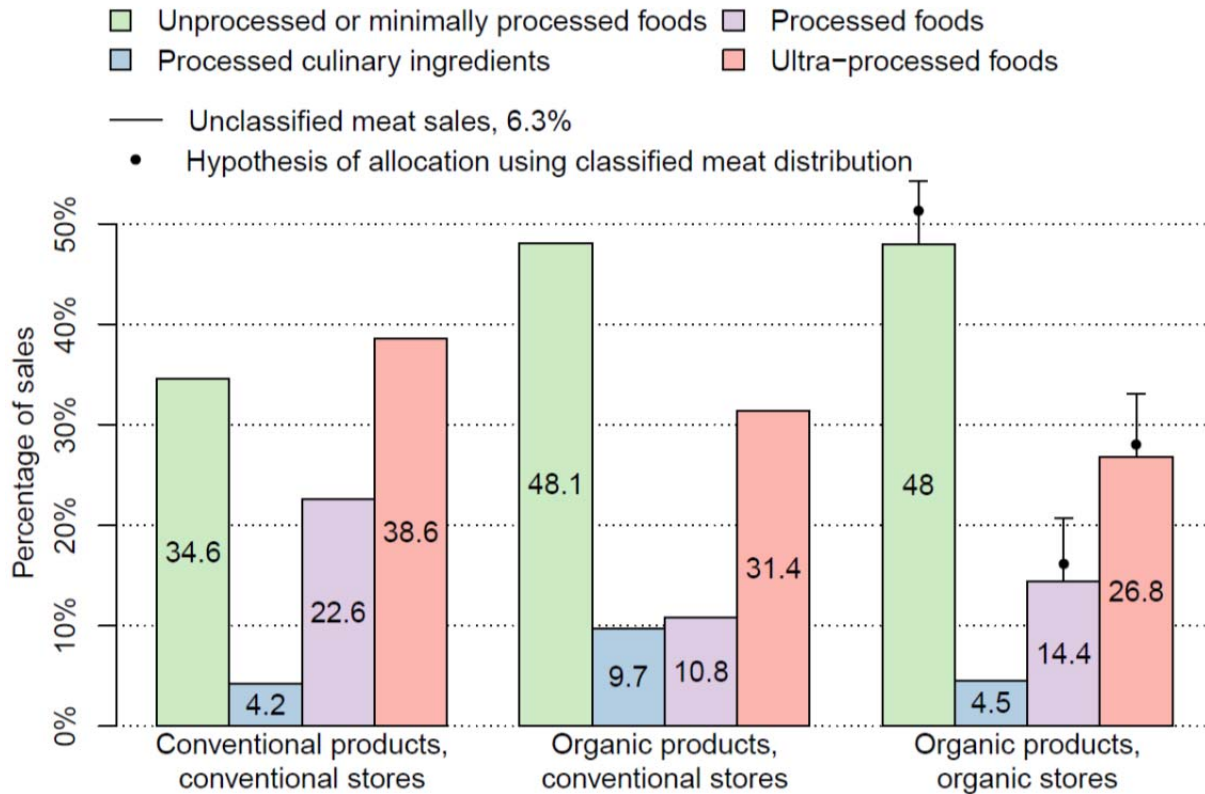
Note: similar to Figure 1, this figure shows that 34.6% of conventional sales in conventional stores are unprocessed or minimally processed foods, 4.2% are processed culinary ingredients, 22.6% are processed foods and 38.6% are ultra-processed foods, with 34.6% + 4.2% + 22.6% + 38.6% = 100%. It depicts the distribution of organic sales in conventional stores with the same structure. For organic stores, the bars and numbers represent the allocation of sales of products that could be classified within the NOVA classification, with 48% + 4.5% + 14.4% + 26.8% =100% - 6.3%. The 6.3% of sales in these stores that could not be allocated within the NOVA classification correspond to meat that could belong to the first, third or fourth classes of the classification. The top of the vertical lines above the bars indicates the percentage of sales in the corresponding class if all 6.3% of the unclassified meat sales were allocated to this class. The points on the vertical lines above the bars indicate the percentage of sales in the corresponding class if the allocation of unclassified meat is the same as the allocation of classified meat, that is, 53% in the first class, 27% in the third class and 20% in the fourth class.

**Figure 3: Sales structure, NOVA classification combined with PAC classification**

Note: Group NOVA 1 Plant includes food products that are unprocessed or minimally processed (class 1 of the NOVA classification) and plant-based. The other groups are defined analogously. The presentation is otherwise similar to that of Figures 1 and 2.

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Figure 4: Sales structure and typology of buyers, PAC classification

Note: this figure shows the sales structure for the PAC classification, similar to Figure 1. It distinguishes our five types of buyers in conventional stores, characterised by increasing organic purchase intensities, and depicts the structure of average sales in organic stores.

Figure 5: Sales structure and typology of buyers, NOVA classification
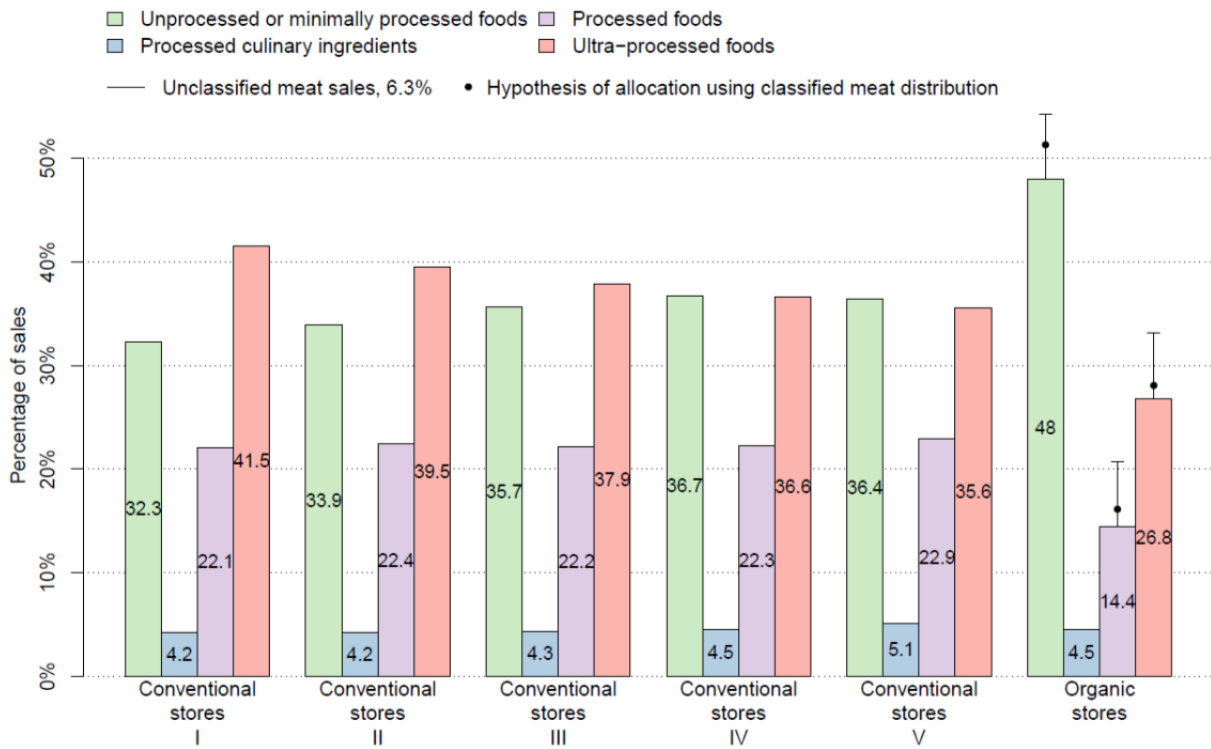
Note: this figure is similar to Figure 4, but with the NOVA classification. The graphical representation of unclassified meat sales in organic stores is similar to that in Figure 2.