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All that glitters is not gold: the impact of the Nutri-score label on food with geographical indication

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Abstract

The European Union is discussing the introduction of a mandatory front-of-pack label to address the rise in nutrition-related diseases. The Nutri-Score (NS) is the most supported candidate in the EU, despite some controversies exist. Specifically, the policy behind the NS system (i.e., the Farm to Fork Strategy—F2F) appears to conflict with the geographical indication (GI) policy, as the same products (GIs) are promoted for their superior quality by the GI policy and frequently classified as products to be avoided by the NS system. Moreover, the NS system, by encouraging the food industry to reformulate products to improve their nutritional quality, places the GIs in a disadvantageous position, due to their strict product specification. To explore the interactions between these two policies, this paper assesses the effect of the NS on retail prices of both GI and non-GI products in the French market, where this system is widely used. A hedonic price analysis was conducted on 254 raw hams (score D or E) through the estimation of a quantile regression model. Results highlight that the presence of the NS decreases the retail price of raw hams, limited to the high-priced segments. Interestingly, the negative effect is consistent for both GI and non-GI hams, suggesting that the GI label does not mitigate the impact of the NS.

Keywords: Farm to fork, Hedonic price analysis, Front of pack, Retail prices, Ham, Quality food products

Introduction

Nowadays, obesity is one of the main nutritional challenges at the European level. In the last 20 years, the age-standardized prevalence of obesity has increased by 1.5 times among adults and has more than doubled among children (World Health Organization 2020; Ng et al. 2014). To tackle this issue, the European Union (EU) is currently adopting different strategies to improve citizens' food choices, and in turn, their dietary behaviours. Likewise, almost 13 out of the 17 Sustainable Development Goals (SDGs) could be linked to the obesity issue, such as SDG2, which aims to end, by 2030, all forms of malnutrition (including obesity), or SDG3, which promotes mental health and well-being, seeking to reduce by one-third premature mortality caused by disease closely linked with obesity, such as diabetes or cancer.

Recent literature has highlighted that nutritional labelling plays a crucial role in consumer decision-making and could be a useful tool to promote healthier dietary behaviours (Fialon et al. 2022). However, different authors (such as Erdem et al. 2022) pointed out some issues linked to the use of nutritional labelling in guiding consumers' choice. To illustrate, due to the time constraints (Grunert et al. 2010; Sanjari et al. 2017) and difficulties in understanding nutritional facts (Campos et al. 2011), consumers frequently ignore label information during grocery shopping. A possible solution to overcome this issue is to use more user-friendly versions of the traditional nutritional labels, namely, the Front-Of-Pack (FOP) ones (Temple 2020). These are graphic labels placed on the front of the package that give concise information about a food's nutritional profile. FOP information is, then, more prominently available during grocery, contributing to reduce potential information asymmetry between consumers and food manufacturers (Verbeke 2005).

So far, in the EU, there is no single and mandatory FOP labelling: companies in the member states can choose whether and which FOP label to adopt (Storcksdieck Gennat Bonsmann et al. 2020). As a consequence, the food industry can take advantage of the voluntary use of the label, endorsing the use of FOP labels only on those products for which they do not risk a potential reduction in sales value (Carter et al. 2013; Temple 2020). To overcome this issue, the EU, within the Farm to Fork Strategy (F2F), stressed the need to implement a mandatory and uniform FOP label among EU member states, to reduce information asymmetry, thus improving citizens' dietary behaviour. The Nutri-Score (NS), first proposed in France in 2017, is the most supported label at European level to fulfil this role, as it is the most efficient system for classifying products, within the same category, according to their nutritional quality (Ducrot et al. 2015a, b; Julia et al. 2016). As a summary label, it provides consumers with clear and easy to understand information about the average nutritional value of the product, using together a chromatic (from green, "healthy", to dark orange, "unhealthy") and an alphabetical scale (from A, "healthy", to E, "unhealthy").

The NS algorithm considers, per 100 g of product, the content of nutrients and foods that should be promoted (fibres, proteins, fruits, vegetables, pulse, nuts, and rapeseed, walnut and olive oils) and those that should be limited (energy, saturated fatty acids, sugars, salt).[1] While desirable from a public health perspective, mandating the label for all products could result in some unintended economic consequences for certain EU quality-certified products, such as GIs. Most animal-based products would indeed be scored with a negative grade (i.e., letter "D" or "E") due to their high level of calories and saturated fats per 100 g of products. Since most GIs are based on animal products, they could suffer market damage by the mandatory use of the NS: consumers could reduce their willingness to pay for a GI product labelled with a negative NS (Stiletto and Trestini 2022). Indeed, it is worth noting that in Europe about 70% of the most sold GI products are of animal origin and their sales value is, on average, twice as much as their similar non-certified counterpart (European Commission 2021). The estimated total sales value of European GIs in 2017 was around 75 billion euros, corresponding to 6.8% of the total EU food and drink sector. This is due to

[1] Specific regulation is available at: https://www.santepubliquefrance.fr/en/nutri-score.

the high quality of GI products recognized on the market, which arises from specific environmental, human, and cultural characteristics that make them unique. Moreover, since the NS is tailored to a 100-g portion, it does not consider that the most common "serving" quantity for these products is significantly below this threshold.

Against this background, it seems that the NS could compromise the GI sector, particularly as GIs must adhere to strict and traditional product specifications and cannot be easily reformulated to improve their NS rating, unlike industrial products. Therefore, it clearly emerged why the NS continues to generate significant debate and faces persistent opposition, especially in Mediterranean countries, as widely discussed in Stiletto et al. (2023). In France, after its initial proposal in 2013 and subsequent adoption in 2017, agri-food companies voiced strong objections (Julia and Hercberg 2016). The European Union's proposal, under the Farm to Fork (F2F) strategy, to make NS mandatory across all member states has broadened the debate. In Italy, NS adoption has become a recurring issue in agricultural policy discussions, with the national government and major agri-food firms arguing that NS disadvantages Mediterranean and traditional products, including wines (Julia and Hercberg 2016; Stiletto and Trestini 2022). Likewise, in Spain, where NS was adopted in 2021, concerns arose over perceived inconsistencies in rating traditional products, such as olive oil, with the NS algorithm was subsequently adjusted to better reflect the nutritional value of olive oil (Fialon et al. 2021).

Despite the importance of the topic, most of the papers on NS have focused on outlining the effectiveness of NS to guide consumers to determine the nutritional value of food products (Ducrot et al. 2015b, a; Julia et al. 2016; De Temmerman et al. 2021), while very few studies have aimed to shed light on the impact of NS labelling on consumers' buying choices (Ares et al. 2018; De Temmerman et al. 2021; De Bauw et al. 2021; Folkvord et al. 2021; Gassler et al. 2022), especially regarding GI products (Stiletto and Trestini 2022; Stiletto et al. 2024). Furthermore, the literature lacks an analysis of the effect of the NS labelling on market sales (Ahn and Lee 2022; Mora-García et al. 2019). To fill this gap, the current study applies a Hedonic Price Model (HPM) to GI and conventional animal products in France, aiming to understand the effect of the use of the NS labelling on retail market prices. HPM, by analysing the variation in prices, allows us to determine the market value of the products in terms of attributes' implicit prices. In perfectly competitive markets, prices are determined by the interaction of supply (which reflects production costs) and demand (which reflects consumers' preferences) (Lucas 1975). However, assuming that the use of the NS does not lead to any additional production costs, in the current study, the estimated implicit price of the NS could be interpreted as a proxy of consumers' preferences, as better discussed in the following section.

The paper is organized as follows: first, a conceptual framework of the HPM is presented; next, data and the empirical model used are illustrated. Results are reported in the third section and subsequently discussed with particular attention to potential policy implications. Final remarks are provided in the last section.

Theoretical background

The hedonic price model (Rosen 1974) is rooted in Lancaster (1966) theory of consumer demand, which postulates that consumers' utility derived from buying a product is not related to the product itself, but to its attributes. This implies that products are

considered as bundles of attributes and price is a function of the implicit prices of these attributes (Rosen 1974). Through the analysis of the variation in prices among products, it is possible to isolate the value associated with each attribute. The HPM is widely used in the agri-food sector across different fields of application and for different products, such as wine (Combris et al. 1997; Costanigro et al. 2007; Oczkowski 1994), milk (Trestini and Stiletto 2020), olive oil (Cavallo et al. 2018), meat (Schulz et al. 2012), seafood (Roheim et al. 2011), and fish (Sogn-Grundvåg et al. 2014). In this context, many authors have shifted the focus on health issues, estimating the implicit value of health and nutrition claims on cereals (Stanley and Tschirhart 2012), hard bread, potato products (Thunström and Rausser 2008), and fruit beverages (Szathvary and Trestini 2014). However, even though a number of studies have focused on consumers' attitudes and stated use of FOP labels, evidence from market data is sparse (Sutherland et al. 2010; Boztuğ et al. 2015; Hamlin 2015; Cawley et al. 2015), especially when it comes to HPMs (Edenbrandt et al. 2018).

HPM is a widely used model, even though it has some flaws. The observed market price depends on both production costs and consumers' preferences (Lucas 1975). Therefore, the HPM is not able to disentangle how much of the market price is due to the supply or demand sides. For example, additional certifications of food products, such as PDO and PGI or Organic labels, significantly affect the price of the products, as these cues are generally evaluated positively by consumers (Savelli et al. 2021) and imply higher production costs, requiring specific production processes (Iotti and Bonazzi 2014). Conversely, when it comes to nutritional labelling, such as the NS, applying this FOP label on food products does not alter the cost structure, unless producers decide to reformulate their products to achieve a better NS value. Indeed, NS calculation is based on information already present on the Back Of Pack (BOP) labels (Reg. (EU) N. 1169/2011) and thus does not require further efforts and costs from firms. It follows that, if a difference in prices exists between products with and without the NS, it could be explained by the value recognized by consumers for the FOP attribute. The estimated implicit price associated with the NS can, then, be considered as the result of the shift in the demand curve and, in a broader context, a proxy for consumers' preferences. Based on this consideration, identifying the effect of the NS on market prices allows us to reveal the impact of this label on consumers' preferences.

Methodology

Data collection

The application of the NS is not yet mandatory within the European Union, and this labelling system is not equally spread and used in all the EU countries. Within this framework, France could be considered the "motherland" of the NS, as it largely promotes and uses this system, reflecting the health authorities' belief that NS can help reduce the obesity epidemic (Santé Publique France 2020). For this reason, several food products available in France are labelled with NS. Moreover, France is the second European country in terms of number of certified products, following Italy, and one of the main importers of Italian PDO and PGI products (ISMEA 2020). Therefore, to estimate the effect of the NS label on food prices, especially on GI products, data was collected in France from April to June 2021.

Table 1 Sales value of the top six biggest French retailers. Source: Journo and Snipes (2018)

Retailer name and Type	Sales in 2017 (in billion USD)	Location	N. of Outlets
E. Leclerc *(Hyper/supermarkets, convenience stores)*	48.2	France and Europe	607
Carrefour *(Hyper/Supermarkets, convenience stores)*	44.6	France and foreign countries	2952
Inrermarche/Les Mousquetaires *(Supermarkets, hard discounter, and convenience stores)*	33.8	France and foreign countries	1836
Systeme U *(Hyper/supermarkets and convenience stores)*	26.2	France	1143
Groupe Casino *(Hyper/supermarkets, hard discount + convenience stores)*	23.1	France and foreign countries	2723
Groupe Auchan *(Hyper /supermarkets, + convenience stores)*	19.6	France and foreign countries	144

Table 2 Descriptive statistics of the sample

	Raw ham		Cooked ham	
	Number	Share (in %)	Number	Share (in %)
References collected	**252**		**406**	
Products bearing PDO certification	19	20.2	0	0
Products bearing PGI certification	75	79.8	0	0
Total	94	37.3	0	0
Products bearing "positive" NS (NS = B)	0	0.0	73	22.1
Products bearing "neutral" NS (NS = C)	0	0.0	232	70.3
Products bearing "negative" NS (NS = D)	118	70.2	25	7.6
Products bearing "very negative" NS (NS = E)	50	29.8	0	0.0
Total Products bearing NS	168	66.7	330	81.3
Products bearing GI and Negative NS (NS = D or NS = E)	65	25.7	0	0.0

In line with previous studies (Carlucci et al. 2014; Fedoseeva 2020), data were collected online, by recording prices and attributes (see "Model specification" section.) of all 658 hams on sale on the e-commerce websites belonging to five of the top six biggest French retailers based in Paris (i.e., Auchan, Carrefour, Casino, E. Leclerc, and Intermarché), as reported in Table 1 (Journo and Snipes 2018). All the "cooked ham" (i.e., *Jambon cuit*) and "raw ham" (*Jambon cru*) listed in the websites of the supermarkets have been included in the database. To guarantee the homogeneity of products and improve the accuracy of the estimates (Caracciolo et al. 2013), any derivative or similar product, obtained with different types of meat—such as chicken and turkey—has been excluded. Indeed, with a larger sample of heterogeneous products, the relationship between prices and attributes could be biased by unobservable products features. As reported in Table 2, among the 658 references collected, none of the 406 cooked hams bears a GI certification. Therefore, in the data analysis process, only raw hams have been considered ($N = 252$).

Model specification

According to Rosen (1974), the price of a product can be interpreted as a function of its attributes. HPM allows for estimating the implicit prices of product attributes, the so-called hedonic prices, through the regression of the price (y) on product characteristics (x). When the relationship between the dependent variable and the explanatory variables varies at different percentiles of the distribution, the Quantile Regression (QR) can be used to calculate a regression curve for each percentile of the dependent variable (Di Vita et al. 2015). In the specific case of NS, QR is adopted to test whether the NS affects homogeneously products of different price quantiles (Fig. 1).

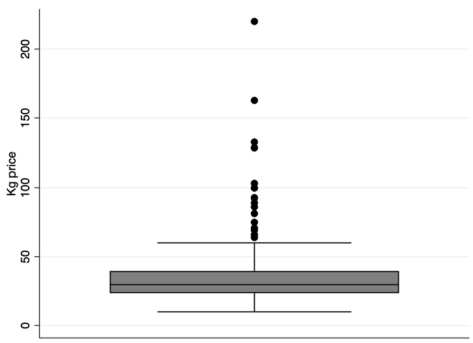
Based on the minimization of the weighted absolute deviations, as described by Cameron and Trivedi (2005), QR aims to estimate the conditional quantile function. The q*th* QR estimator $\widehat{\beta_a}$ minimizes over β_q the objective function (1)

$$Q(\beta_q) = \sum_{i:yi \geq x_i'\beta}^{N} q|y_i - x_i'\beta_q| + \sum_{i:y<x_i'\beta}^{N} (1-q)|y_i - x_i'\beta_q| \quad (1)$$

where $0 < q < 1$ and β_q is used rather than β to highlight that different values of q estimate different values of β. A double-log functional form has been selected in the present study, based on the Box-Cox (1964) transformation, with the log–log transformation specifically applied to the continuous variables (price and product size), as all other variables are dummies. This transformation was used to determine the best functional form among those applicable, in line with previous studies (Halstead et al. 1997; Trestini et al. 2020; Rossetto and Galletto 2019). In QR, that is a semi-parametric estimation, the residuals are calculated through bootstrapping and due to the lack of assumptions about the error distributions, QR is more robust to outliers than the ordinary least squares.

Given the large number of product attributes (more than 50) present on the e-commerce website (brand, size, product presentation, nutritional claims, quality certifications, and price discount), a Forward Stepwise regression was previously performed to identify the variables to include in the model, according to their statistical significance. The attributes considered in the QR are reported and described in Table 3.

a)



b)

	References in category	
Price / Kg	In number	in percentage %
9.95-15.0€	15	5.96%
15.0-20.0€	24	9.52%
20.0-25.0€	40	15.87%
25.0-30.0€	54	21.43%
30.0-35.0€	37	14.68%
35.0-40.0€	24	9.52%
40.0-45.0€	17	6.75%
> 45.00€	41	16.27%

Fig. 1 Box-plot price distribution (per kg) at different percentiles (**a**) and price range (**b**)

Results

Results of the simultaneous quantile regression are reported in Table 4. All the variables are statistically significant at least at 10%, except for the presence of NS in Q25, and for the interaction between the presence of the NS and the presence of the PDO certification—Parma PDO or San Daniele PDO—(*NS*PDO*) for all the quantiles. As expected, *Product size* has a negative impact on prices (β_{size} ranging from −0.135 at Q25 to −0.262 at Q50): the larger the package size, the lower the price (per kg), due, very likely, to economies of scale in package and logistic costs or to consumer preference for these product formats. The same goes for the product presentation: bulk products have lower prices (β_{bulk} ranging from −0.453 at Q25 to −0.585 at Q50) than packed ones. The breeding technique has the most important impact on retail prices, as Pata Negra breed ($\beta_{Pata\ Negra}$ ranging from 1.207 at Q25 to 1.416 at Q75) has a premium price, estimated following Kennedy (1981), equal to (+) 229.4% at Q25 and to (+) 305.1% at Q75. In the same vein, quality certifications have a positive impact on product prices. Specifically, Parma PDO certification (β_{Parma} ranging from 0.338 at Q75 to 0.380 at Q25) has a premium price equal to (+) 48.5% at Q75 and to (+) 105.6% at Q25; San Daniele PDO ($\beta_{Daniele}$ ranging from 0.398 at Q75 to 0.725 at Q25) is equal to (+) 48.5% at Q25 and to (+) 105.6% at Q75, and Organic label ($\beta_{Organic}$ ranging from 0.589 at Q75 to 0.775 at Q25) is equal to (+) 78.4% at Q75 and to (+) 114.7% at Q25. On the contrary, the private label ($\beta_{private\_label}$ ranging from −0.241 at Q75 to −0.312 at Q75) decreases prices by (−) 27.1% at Q25 and to (−)21.5% at Q75. When it comes to the effect of the NS ($\beta_{NS\_D\ or\ NS\_E}$ ranging

Table 3 Descriptive statistics of the raw ham sample (variables included in the model)

Variable	Type	Mean	Std. Dev	Price level (€/kg)	
				Mean	Std. Dev
Product size (in grams)	C	116.25	4.31		
Product presentation					
Bulk (= 1)	D	0.05	0.21	23.10	5.82
Other				36.08	24.20
Breeding technique					
Pata Negra* (= 1)	D	0.03	0.16	117.03	25.24
Other				33.14	19.27
EU Quality certification					
Parma PD = (= 1)	D	0.06	0.23	44.05	13.89
Other				34.96	24.19
San Daniele PDO (= 1)	D	0.02	0.14	50.15	5.05
Other				35.17	23.95
Organic (= 1)	D	0.04	0.19	60.42	16.27
Other				34.54	23.56
Brand					
Private label (= 1)	D	0.48	0.50	30.47	20.49
Other				40.01	25.72
Nutri-Score					
NS D or NS E (= 1)	D	0.67	0.47	33.95	25.90
Other				38.49	18.74

D, dummy variable; C, continuous variable

*Pata Negra label could be applied only on 100% Iberic ham, obtained from pigs fed on acorns and natural herbs

Table 4 Results of quantile regression

Variable	Q25			Q50			Q75		
	β (Std. Err)	*p* value	Premium price	β (Std. Err)	*p* value	Premium price	*β* (Std. Err)	*p* value	Premium price
Product size (in grams)	−0.135 (0.074)	*		−0.262 (0.077)	***		−0.260 (0.103)	**	
Product presentation									
Bulk	−0.453 (0.128)	***	−36.9%	−0.585 (0.133)	***	−44.8%	−0.485 (0.162)	***	−39.2%
Breeding technique									
Pata Negra	1.207 (0.174)	***	229.4%	1.284 (0.242)	***	250.6%	1.416 (0.187)	***	305.1%
Quality certification PDO									
Parma PDO	0.380 (0.097)	***	45.6%	0.342 (0.155)	**	39.0%	0.338 (0.137)	**	38.9%
San Daniele PDO	0.725 (0.096)	***	105.6%	0.528 (0.071)	***	69.2%	0.398 (0.073)	***	48.5%
Organic	0.775 (0.144)	***	114.7%	0.632 (0.150)	***	86.1%	0.589 (0.142)	***	78.4%
Brand									
Private label	−0.312 (0.092)	***	−27.1%	−0.247 (0.057)	***	−22.0%	−0.241 (0.040)	***	−21.5%
Nutri-Score									
NS D or NS E	−0.047 (0.118)	n.s	−5.2%	−0.136 (0.070)	*	−12.9%	−0.129 (0.044)	***	−12.2%
NS*PDO	0.049 (0.113)	n.s	4.3%	0.028 (0.046)	n.s	2.7%	0.037 (0.036)	n.s	3.7%
Cons	3.969 (0.365)	***		4.808 (0.377)	***		4.912 (0.492)	***	
Pseudo-R^2	0.31			0.35			0.44		

asterisks denote the levels of significance: * for *p*-value < 0.10, ** for *p*-value < 0.05, and *** for *p*-value < 0.01

from −0.129 at Q75 to −0.136 at Q50), which is the core of the current study, it emerged that a raw ham labelled with NS (NS = D or NS = E) is associated with lower prices only for medium- and high-prices products, equal to (−) 12.2% for the high-priced ones and to (−) 12.9% for the medium-priced products. It should be stressed that raw hams could have only a negative score, as reported in Table 2. Thus, the NS has a negative impact on prices. Besides, the interaction between the NS and the GI is not significant for any of the quartiles. It should be noted that this interaction term reflects the joint effect of the presence of the NS label and of the PDO label (either Parma PDO or San Daniele PDO). Therefore, there is no evidence that the presence of the quality certification (PDO) is able to "protect" the product from the negative impact of the NS.

The graphical representation of the coefficients, reported in Fig. 2, highlights the variability of implicit prices at different percentiles of price. Even though the variability is generally low, these figures allow us to capture the trend of the NS estimated coefficients at different price levels. Contrary to what was assumed, it emerged that the presence of the NS has a greater impact on high-priced products, as the coefficient is statistically different from zero at 5% only at Q75. In the higher quantiles (Q50 and Q75), the point estimates (and reported in Fig. 2) suggest that the application of the NS on food packages is associated with a decrease in price that is around (−) 12–13%. Since the

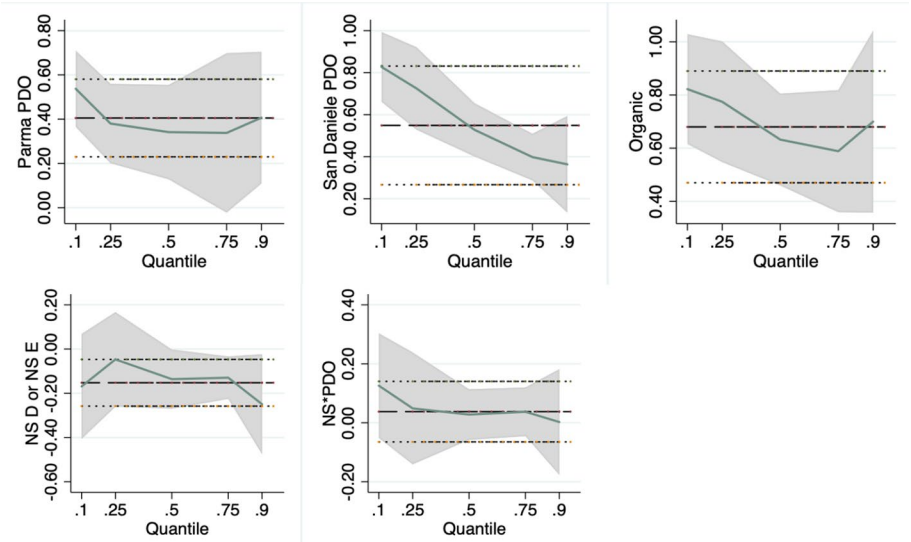


Fig. 2 Estimated coefficients of the quantile regression and 95% confidence intervals for the explanatory variables. *Note*: QR and OLS coefficients and confidence intervals for each regressor as quantile varies from 0 to 1. Horizontal lines in the graphs are the OLS point estimates and confidence intervals (these do not vary with the quantile). Plots show, moreover, trends of quantile regressions that are the variation of estimated coefficients within quantiles (from 0 to 1) with confidence intervals (shaded grey areas)

dependent variable is in logs, the coefficient of the dummy variables can be interpreted as semi-elasticities. On the contrary, the interaction effect between the PDO and the NS is not significant in any of the price percentiles.

Along with the information derived from the NS coefficient, Fig. 2 gives some interesting insights also about the dynamic of the regression coefficients of the explanatory variables. To illustrate, among the different quality certifications, it emerged that San Daniele PDO has a different effect depending on prices. Specifically, the presence of the PDO generates an increase in prices that is three times higher for the low-priced products than for the high-priced ones. On the contrary, the effect of the Parma PDO and the Organic certification is similar across all the percentiles and is well described by the average effect expressed in the Q50. The same goes for the product presentation, the breeding technique, and the private label.

Discussion

Unsurprisingly, quality certification variables are statistically significant in determining the attribute premium in price (Parma PDO, ranging from + 38.9% to + 45.6%; San Daniele PDO, from + 48.5% to + 105.0%; Organic, from + 78.4% to + 114.7%). As widely emphasized by many authors (Resano-Ezcaray and Sanjuàn-Lòpez 2008; Resano-Ezcaray et al. 2010; Savelli et al. 2020), PDO (and PGI) labels significantly affect food sales (and therefore the equilibrium price), being one of the key attributes in buying choices. As found by Savelli et al. (2020), these product cues have such a role in determining consumers' preferences that the presence of the PDO (or PGI) labels can even improve consumers' sensory perception to these products. Staudigel and Trubnikov (2022) found similar results for the Organic cue, stressing the price premium attached to this attribute for both red and white meat. On the supply side, PDO and PGI products are

characterized by specificity in the production methods that increase production costs and therefore retail prices. Among the quality attributes analysed in the model, Fig. 2 clearly shows a slight variability (even though it is the largest compared to the other labels) in the distribution of the "San Daniele PDO" coefficient across percentile: the lower the price, the greater the positive effect of the Denomination.

The same goes for the "Pata Negra" attribute, which has the highest impact on the price (+305.1% at Q75). Only hams "100% Iberico" produced by pork fed with acorns can bear the Pata Negra label[2] (Real Decreto 4/2014[3]). This breeding technique entails higher production costs compared to the base product, which is reflected in the higher price of the final product. Moreover, we can argue that this product may benefit from higher preferences from the demand side, but no evidence has been highlighted by previous research, to the best of our knowledge.

When it comes to the product presentation, results indicate a decrease in prices for bulk products compared to the packaged ones (ranging from −36.9% to −44.8%), due to the economies of scale (Schamel 2007) and the lower costs associated with reduced services. The same goes for the Private labels (from −21.5% to −27.1%), notoriously cheaper than branded products (Bronnmann and Hoffmann 2018).

Regarding the core of the research, namely, the NS, results underline a decrease in prices for the products bearing a NS label. Conversely, recent scholars (see for instance De Temmerman et al. 2021) argue that the presence of the NS significantly affects consumers' purchasing intention for healthy products, thus increasing them, but does not alter consumers' buying choices for unhealthy products. However, what found by De Temmerman et al. (2021), albeit in a hypothetical context, is somewhat implausible due to the demand saturation for food consumption. If sales of healthy products increase while those of unhealthy products remain unchanged, this would imply that there will be a general increase in consumption and not just a change in it, as it is often the case (Cirera and Masset 2010). Yet, since the implicit price of the NS could be considered as the expression of the effect of solely consumers' preferences—and not of the supply side ones, as widely discussed in a previous paragraph—the estimated coefficient for NS variable is the result of the leftward shift of the demand curve. It can therefore be inferred that consumers are less likely to buy or less willing to pay for products with negative NS, in line with what found by Egnell et al., (2018) and by Julia et al., (2017), based on stated preferences.

This applies even to products generally valued by consumers, such as GIs, for which consumers are typically willing to pay a premium. Recent literature shows a growing tendency for consumers to view GIs not only as traditional but also as healthy options (Glogoveţan et al. 2022; Thøgersen and Nohlen 2022), even though these health-related perceptions may lack clear evidence. Nonetheless, as widely discussed in the paper, many animal-based GIs—particularly in the cheese and cured meat categories—receive a low Nutri-Score, despite PDO products generally being free from additives and minimally

[2] Pata Negra, while not officially designated as a PDO (Protected Designation of Origin), can still be associated with specific Denominations of Origin when production is restricted to designated areas, as in the case of "PDO Los Pedroches". For these products, production is confined to the *dehesas* located in the Sierra de Los Pedroches region, which, where the unique climate contributes to the creation of hams with a notably less fibrous texture.

[3] https://www.boe.es/diario_boe/txt.php?id=BOE-A-2014-318.

processed (Höhn et al. 2023). Consequently, when consumers see a low NS value associated with products they perceive as healthy, they may experience a reduced sense of satisfaction, as found also in other studies (Stiletto et al. 2024).

This generates significant economic implications not only for producers located in countries where the NS is adopted on a voluntary basis, but also for exporting regions. Indeed, the NS can be applied by both producers and retailers on private label products. Thus, even those producers who opt not to label their products with the NS may still be impacted by this label if their products are sold in markets where retailers choose to apply it. As a consequence, sales (or exports) may decrease and the market price of the products could drop, thus diminishing the producer's surplus. Yet, introducing the NS labelling system could also reduce consumers' surplus related to the consumption of these products, as consumer preferences may shift away from products with lower scores, which are perceived as less healthy. This shift causes the demand curve for such products to move leftward, reflecting a reduced willingness to purchase at previous price levels. As the overall demand decreases, equilibrium prices and quantities in the market also fall, leading to a reduction in consumer surplus.

In terms of public health, it should still be emphasized that the negative effect of the NS on certain product categories (including raw hams) aligns with the objectives set by the European Commission, aiming to reduce the consumption of products high in saturated fats and calories. However, QR estimates suggest that, for low-priced raw hams, the NS is ineffective on the demand side and therefore on preferences of consumers of such products and only high price hams suffer the negative effect of the NS. This suggests that consumers with budgetary constraints that buy low price goods do not care about NS. This may lead to the opposite of the desired results, considering that obesity seems to be most pronounced in economically disadvantaged groups (Withall et al. 2009).

Policy implication

Results of the QR clearly suggest that the presence of the NS has a significant effect on the price only for high-priced products, meaning that the NS does not have a homogeneous effect on all the products analysed, leading to potential market biases. As reported in Tables 3 and 4, the most expensive products are generally those with some Quality certification, such as the Protected Designation of Origin or the Organic labels. It follows that EU Quality products could be the most damaged by the adoption of this FOP labelling, as suggested by Stiletto and Trestini (2022): consumers are generally willing to pay less for PDO products bearing a negative NS. Hence, in light of introducing the NS at the European level, such as other similar labels, consumers will continue to buy products with Designations of Origin only if they are cheaper. Put differently, these products, protected by the EU because of higher quality (Reg 1151/2011), will be to some extent devalued. This is strengthened by the fact that the PDO logo does not have an halo effect (i.e., the extension of the value given to a products characteristic, such as the Denomination, to the product itself, as defined by Thorndike 1920) on the general evaluation of the products, as the interaction between PDO and NS is not statistically significant in the QR, in line with recent findings (Stiletto and Trestini 2022). However, for well-known GI products sold in domestic markets, the effect of NS could be different. As

Stiletto et al. (2024) found in the case of Parmigiano Reggiano sold in the Italian market, the positive value attached to the PDO label fully offsets the negative effect of the NS (NS = D). According to several authors (Deselnicu et al. 2013; Leufkens 2018), price premiums for GI are generally dependent on the product, the specific GI, and the reference market. Parmigiano Reggiano PDO and Parma PDO are prime examples of the strong influence of well-established Consortia labels, which consumers perceive as reputable brands (Arfini 1999). However, it should be noted that while these products are very well known in Italy, they are less recognized abroad. As highlighted by Zhang et al. (2023), consumers typically have a higher purchase intention for local GI brands, as the consumer-brand connection is stronger for these products, with greater consumer involvement with the GI brand. This partly explains why Parmigiano Reggiano PDO 'protects' the product from the negative effect of NS in the Italian market, while the same effect is not observed for Parma PDO in France.

In broad terms, it can be assumed that the European Union is promoting two contrasting policies at the same time: the F2F (at least within the social dimension of sustainability, related to the nutritional aspects), which bolsters the NS adoption at the European level, and the EU GI policy, which supports the PDO and PGI products for their quality. Even if the two policies focus on different aspects, as the F2F strategy, through the adoption of the NS, supports the most nutritionally sound products, and the GI policy promotes the quality of the protected products for their link to the territory and their traditional know-how, the effect is nevertheless contrasting. Indeed, PDO products are praised on the one hand (GI policy) and condemned on the other (F2F), creating confusion among consumers and underlining the risk of a paradox in the EU legislative proposal. Moreover, the F2F strategy, which aims to address all dimensions of sustainability, also prioritizes other facets of social sustainability, such as bolstering the local economy. This alignment is consistent with the GI policy. Indeed, GIs play a pivotal role in fostering local economic development, a core aspect of the F2F strategy, aimed at building a resilient food system and ensuring fair incomes for producers (Crescenzi et al. 2022). Therefore, supporting the NS at EU level would reveal, to some extent, an internal inconsistency of F2F. Hence, the European Commission should consider these aspects.

Some proposals currently on the table concern the use of alternatives FOP labels or the exclusion of GI products from the mandatory NS system. However, excluding only GIs from this labelling system could still result in an undesirable effect, as consumers, not seeing the NS, might be confused and suspicious of the value of GI products. Alternatively, some improvements could be made to the NS profiling system, considering the actual package size, especially for the ready-to-eat products, or estimating the nutritional score based on the serving size, namely the consumption intake recommended by nutritionists considering the daily reference intake. In this way, some PDO products (such as Prosciutto di Parma PDO or Parmigiano Reggiano PDO), which are generally consumed in much smaller quantities than 100 g (the recommended dose is 50 g for Prosciutto di Parma PDO and 20 g for Parmigiano Reggiano PDO), might not be penalized.

Against this framework, nutrition education campaigns should be promoted and supported along with the use of the FOP label, not only to educate consumers to follow a healthier and more balanced diet, but also to guide consumers in the proper interpretation of the NS label. Saying that the "overall nutritional value" of a product is "not good"

is completely different from saying that the product should be "consumed in moderation" (Hercberg et al. 2021). Likely, the first wording leads consumers to deem that a product with a NS rating of D or E should be always avoided, due to its low quality. The second, on the other hand, helps them to understand to what extent they should consume that specific product to follow a balanced diet. Therefore, a clear way of interpreting the NS label should be defined and provided to consumers, especially in the period following its mandatory introduction, considering that consumers in different countries have different levels of familiarity with the label, a key factor in the objective understanding of the labels (Santos et al. 2020).

Conclusions

Current paper aims to shed light on the price premium generated on animal products by different attributes, with particular attention to the GI products. More in-depth, this study aims to understand the effect of the application of the NS labelling on retail market prices through the estimation of a Hedonic Price model. Results suggest that, despite GI certifications benefiting from the highest premium price, the presence of a negative NS implies a negative effect on both GI (at least for the upper-tier goods) and conventional products. In other words, the NS label could significantly change market equilibrium, affecting not only the adopting countries but also the exporting ones. Producers not using the NS may still face reduced sales and lower market prices if their products are sold in markets where the NS is used, leading to decreased producer surplus. Additionally, by shifting demand away from lower-scoring products, the NS could reduce equilibrium prices and quantities.

Against this framework, it should be stressed that the implicit price of the NS could be interpreted as the sole effect of consumers' preferences, as adding the NS to a food product does not imply any additional cost for producers if they do not reformulate their products. Therefore, the decrease in prices emerged in the study could be interpreted as the result of the sole reduction of consumer utility for a negative NS-labelled product. However, results underline that the NS negatively and significantly affects the price only for high-priced products, which likely are those bearing some quality certification, such as PDO or Organic products. It follows that the NS implementation at EU level could damage most of GI products: consumers are willing to pay GI products less and/or consume them less. Furthermore, our results highlighted another weakness in the F2F strategy: by penalizing only high-priced products, the NS system is more likely to be ineffective for "price-driven" consumers. These consumers are, in general, the target of policies aimed at combating malnutrition and diet-related issues. This could lead to a negative impact on the consumer surplus, particularly affecting demand for high-quality products. Further studies are therefore needed to assess more in-depth the efficiency and effectiveness of the NS system on the diet consumption habits of the EU citizens, as well as to estimate the economic drop caused by the NS policy on GI products.

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Author contributions
Stiletto, Alice contributed to conceptualization, methodology, writing—original draft preparation, writing—review & editing, formal analysis, investigation. Cembalo, Luigi helped in methodology, writing—review & editing. Trestini, Samuele contributed to conceptualization, methodology, resources, writing—review & editing, supervision, investigation.

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