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Abstract

Geographical Indications (GIs) are considered as upmarket products because they are based on tradition and convey information about their geographical origin. Otherwise, the limitation of the geographical areas devoted to GIs and the exclusivity they benefit on the product lead to suspicions of monopoly power. Quality and market power should however reflect a stronger attachment, making consumers less price sensitive than for standard goods. This research aims to compare theses conjectures to empirical measures concerning the French cheese market. Price elasticities are computed from a demand model on 21 products, 11 Protected Designation of Origin (PDO) products and 10 non PDOs. The results are counterintuitive, PDOs being as price elastic as or more price elastic than standard products. This finding thus challenges the widespread idea that PDOs systematically correspond to high quality. It also has important implications in terms of competition policy, showing that PDO cheeses suppliers cannot decide on price increases without suffering large reductions in demand.

Keywords: Geographical indications, demand model, price elasticities, competition policy
JEL: C51, D12, Q18

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1. Introduction

Protecting Geographical Indications (GIs) is one of the long-standing European public policies devoted to the modernization of the agro-food sector.[1] GIs are public and collective brands allowing atomistic farmers to address the quality signalling issue (Akerlof, 1970). An important related objective is to keep a rural population in disadvantaged or isolated areas. Since 1992, the national systems protecting GIs have been unified in a European measure extended to all agricultural products and foodstuffs, based on the Protected Designation of Origin (PDO).[2] To be eligible to use a PDO, a product must provide arguments of a close tie to its "terroir", a term which refers to a delimited geographical area where natural elements (climate, soil) are combined with human factors related to traditional know-how and recipes. In return for these requirements, the label assures the producers exclusivity on the product, prohibiting the use of its name by producers located outside the area, even if they comply with the requirements.

New World countries and European competition authorities have pointed out the risks of control supply and coordination between producers, resulting from delimited production areas and from the production exclusivity (Lucatelli, 2000; Babcok and Clemens, 2004; Evans and Blakeney, 2006). Quality and market power should however reflect a stronger attachment to GIs, making consumers less price sensitive than for standard goods. This

[1] Motorization, land and supply concentration through incentives to cooperatives along with quality improvement and quality signaling are the main policies implemented since the 1950's to modernize European agricultures.

[2] The French "Appellation d'Origine Contrôlée" which inspired the European PDO was established for the wine and spirits sector in 1935 and extended to cheese (1955) and then to all processed and unprocessed agro-food products (1990). Since 1993 and excluding wines and spirits which are the subject of another regulation (1493/1999), the EU possesses over 700 registered GIs, designating over 150 cheeses, 160 meats and meat-based products, 150 fresh or processed fruits or vegetables and 80 types of olive oil (Evans and Blackney, 2006). In addition to the PDO, the European system includes the Protected Geographical Indication (PGI) which differs from the former in terms of intensity of the requirements.

research aims to compare this conjecture to empirical measures concerning the French cheese market where the global PDO market share (17.3% in volume and 21% in value) is higher than in most sectors.[3] Price elasticities are computed from a demand model distinguishing PDO cheeses from non PDO cheeses.

The paper is organized as follows. After an overview of previous studies related to GIs and to price elasticities in section 2, section 3 presents the data and the main characteristics of the cheese market. Section 4 introduces the model. Section 5 sets out and discusses the results. Section 6 concludes.

2. Previous studies

2.1 GIs: quality and welfare

Most economic models have adopted the cartel assumption in a context of vertically differentiated products, PDOs being the high quality. The question is then whether supply restrictions can be welfare improving. Giraud-Héraud, Mathurin and Soler (2003) justify supply restrictions arguing that quantity and quality are negatively correlated. Crespi, Marette and Schiavina (1999) and Lence et al. (2007) consider pricing over marginal cost necessary to cover the fixed costs associated with the introduction of quality products on the market. Moschini, Menapace and Pick's framework (2008) differs in that GIs are competitive organizations. According to these authors, in most cases, no scarcity factor constrains supply and anti-trust policies are efficient against anti-competitive practices.

Case studies are important to assess the stylized facts. In a study on three farmer-owned brands, Hayes, D. J., Lence, S. H. and Stoppa (2004) do not detect much antinomy with the anti-trust regulations. Examining two PDO French cheese cases, Colinet and al. (2006) confirm Moschini, Menapace and Pick's assumption that the limitation of the area of production is rarely binding.

Quantitative papers are not directly related to GIs acceptability but they provide important insights. Bonnet and Simioni (2001) find that even if the two products were at the same price, consumers choosing a PDO Camembert cheese rather than the pasteurized version would remain in the minority. This finding questions the basic assumption of vertical differentiation between PDOs and non PDOs products. Studying the willingness to pay for renowned PDO Spanish veal, Loureiro and McCluskey (2000) show that the largest willingness to pay does not benefit the highest quality cuts but instead the intermediate quality. In the same vein, according to Hassan and Monier

[3] The only exception is the wine industry. However, a comparison of consumers 'attachment to PDOs versus standard products in the French wine sector is of little interest, the two product categories being hardly comparable. Indeed, non PDO wines refer to very low quality whereas intermediate and high quality wines are only PDOs. Otherwise, PDOs correspond to their "terroir" of origin (Bordeaux, Bourgogne...) while standard products are only branded products.

(2006), the valorisation of the PDO attribute is higher when the label is associated with a store brand instead of being related to a reputed national brand. In the two situations, the PDO plays the role of quality assurance for standard products. More recently, Mérel (2009) established that the PDO organization of Comté cheese holds only very little market power.

2.2 Price elasticities: a measure of consumers' attachment to products

Consumer's attachment is a complex notion which translates into consumers' sensitivity to price variations and can be captured through the price elasticities of demand: the lower the own-price elasticity (in absolute terms), the stronger the attachment to the good.[4]

Several economic models have explored the relationship between quality and price elasticity. In their pioneering paper, Mussa and Rosen (1978) find that a monopoly proposing two vertically differentiated qualities gets larger profits in absolute terms from the higher quality but lower in relative terms. Adopting a duopoly framework and assuming search costs on the high quality segment, Verboven (1999) finds larger profits both in absolute and relative terms for the high quality. Relying on a monopolistic competition model allowing for horizontal and vertical differentiation, Coibion, Einav and Hallak (2006) point out that most economic forces such as the scope for product differentiation and consumer's price sensitivity are likely to induce lower equilibrium demand elasticities for higher quality products.

Many empirical analyses also find that quality lowers price elasticities. Hausman, Leonard and Zona (1994) and Pinkse and Slade (2004) refer to price sensitivities to explain that on the beer market, expensive premiums are less price elastic than common beers. Berry, Levinsohn and Pakes (1995) find that upmarket cars have the lowest direct price elasticities and conjecture that consumers self select themselves on market segments according to their income.

Relying on large observations samples on several products categories, Tellis (1988), Dietche, Bayle-Tourloutou and Kremer (2000) and Bijmolt, Heerde and Pieters (2005) found that product category, brand concentration, advertising and price dispersion were important determinants of price elasticities. Using individual data, Hoch et al. (1995), Mulhern, Williams and Leone (1998) and Bertail and Caillavet (2007) highlighted the impact of demographic characteristics. Vilas-Boas and Winer (1999), Dhar, Chavas and Gould (2003) and Bijmolt, Heerde and Pieters (2005) demonstrate that controlling for the endogeneity of prices and revenue has a strong impact on elasticities, revealing consumers more price sensitive.

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[4] Merunka, Changeur and Bourgeat (1999) pointed out that demand variations may occur not only in reaction to prices but also to non price shocks, for example a reduction in the shelf space devoted to the product by the retailer. However, this feature holds mainly for some specific outlets, in the short term.

Several papers have estimated complete food demand systems for the European countries, considering cheese as a single aggregate.[5] Bouamra et al. disaggregated the French cheese sector into six product categories (soft, hard, semi-hard, blue, fresh and processed). In the present paper, we constructed a data base likely to distinguish between PDOs and non PDOs and to reflect part of the French cheese market diversity.

3. The French cheese market: data and main features

We used home scan data from the Kantar Company, providing information on cheese purchases made in France between 1998 and 2003 by a representative sample of consumers including more than 8,000 households. The database distinguishes 129 original cheese products and makes it possible to separate PDO from non-PDO cheeses. Such a large set of products is obviously not directly usable. The first reason is computational: a demand system on 129 alternatives would lead to estimating more than 10,000 cross-price parameters. The second reason is that most products having tiny market shares, too few purchase data are available for them, even at the highest level of aggregation.

We selected the most famous cheeses (11 cheeses) such as Camembert, Roquefort or Brie, even if the market share is small. Other cheeses are aggregated (10 aggregates) with respect to the manufacturing process: current soft, soft pressed, other soft (i.e. soft cheeses "à croûte lavée"), hard, blue, goat, spread and fresh. We thus consider 21 products, 11 of them being PDOs and 10 non PDOs (see table 1).

Table 1: Average market shares and prices for each of the 21 cheeses between 1998 and 2003

Products	***Expenditure shares***		***Price (€/kg)***
	Volume (%)	Value (%)	
Current Soft Cheeses (CSC)			
1.PDO Camembert (CSC)	1.3	1.3	7.6
2.Non PDO Camembert (CSC)	11.2	8.1	5.6
3.PDO Brie (CSC)	0.8	0.9	8.8
4.Non PDO Brie (CSC)	2.8	2.1	5.8
5.Other PDO CSC	0.3	0.4	8.9
6.Other Non-PDO CSC	15.1	13.0	6.7
Soft Pressed Cheeses (SPC)			
7.Cantal (PDO)	1.5	1.4	7.5
8.Other PDO SPC	3.2	3.8	9.1
9.Other Non-PDO SPC	14.6	14.7	7.8
Hard Cheeses (HC)			
10. Emmental (Non PDO)	11.3	9.3	6.4
11.Comté (PDO)	4.1	4.8	9.0
12.Other PDO HC	1.1	1.6	11.1
13.Other Non PDO HC	1.6	1.7	8.6

[5] Bouamra et al. (2008) provide a survey on studies concerning European countries.

Blue Cheeses (BC)			
14.PDO BC	1.3	1.3	7.6
15.Non PDO BC	2.2	2.9	10.1
16.Roquefort (PDO)	1.7	3.2	14.7
Other Soft Cheeses (OSC)			
17.Munster (PDO)	1.0	1.0	8.3
18.Other PDO OSC	1.0	1.3	9.7
19.Other non-PDO OSC	1.4	1.9	10.4
20.Spread cheeses and fresh cheeses	16.3	17.2	8.2
21.Goat cheeses	6.1	8.1	10.3
PDO Cheeses	17.3	21.0	9.3
Non PDO Cheeses	82.7	79.0	8.0

(Source: Kantar WorldPanel Data)

PDOs are raw milk cheeses, which makes them tastier than non PDOs, based on pasteurized milk.[6] Raw milk generates additional processing costs and may be associated in consumer's mind with some health risk. Table 2 compares PDO and non PDO cheeses according to several characteristics: purchasing habits, scope for product differentiation, brands concentration, income and mean price. Table 3 is the matrix of correlations between all these variables plus the dummy PDO.

Purchasing habits are measured by the average number of purchasing acts per year during the 1998-2003 period. The extent of product differentiation is approached by the coefficient of variation of the price (CVP) which, for each product, reflects both the number of models and the market structure. This measure is consistent with a qualitative approach of product differentiation, obtained by quoting one (or zero) if some differentiation does exist (or not) for each product characteristic (packaging, tastes, weights…) and summing across the characteristics (correlation between the two indexes is 0.52, see table 3). Brand concentration is measured by the market share of the first four brands (CR4), each store brand being considered as a distinctive brand.[7] Income is the mean revenue per family member (children are accounted according to their age) of all the households having purchased the good at least once over the period.

[6] Nowadays, the process is sometimes facilitated by replacing raw milk by "thermisé" milk, in which milk is heated but less than for pasteurization, in order to keep part of the microbial flora alive.

[7] An alternative measure to the CR4, the Herfindhal index, provides equivalent results (the coefficient of correlation between the two indexes is 0.888).

Table 2: Comparison between PDO and non-PDO products according to several characteristics (standard deviations are given into brackets)

Variables	*Total mean*	*Mean for PDOs*	*Mean for standard cheeses*
N^ber^ of observations	21	11	10
Purchasing frequency (N^ber^ of purchases)	28757 (7106)	9550 (1703)	49885 (11723)
Coefficient of Variation of Price (CVP)	27.8 (9.5)	24.2 (8.3)	31.8 (9.6)
Qualitative approach of differentiation (QAD)	3.5 (2.4)	1.9 (1.0)	5.2 (2.3)
Brand concentration (CR4)	35.6 (23.1)	31.7 (23.1)	40.7 (20.5)
Purchasers monthly income per family member	1058.7 (194.3)	1130.8 (208.9)	979.4 (148.8)
Mean price	8.7 (2.0)	9.3 (2.1)	8.0 (1.8)

(Source: Kantar WorldPanel Data)

Table 3: Matrix of correlations between product characteristics

	PDO	*Purchases*	*CVP*	*QAD*	*CR4*	*Income*	*Price*
PDO	–						
Purchases	-0.634**	–					
CVP	-0.406*	0.523**	–				
QAD	-0.696**	0.717**	0.521**	–			
CR4	-0.199	-0.173	-0.385*	-0.064	–		
Income	0.399*	-0.151	-0.194	-0.215	0.254	–	
Mean Price	0.335	-0.330	-0.001	-0.159	0.239	0.169	–

*Statistically significant at a * 0.10 level; ** 0.05 level; *** 0.01 level.

Compared to non PDO goods, PDOs are mainly niche: purchasing frequency, negatively correlated with the dummy PDO, is only 20% of that observed for standard cheeses. Product differentiation in the cheese sector diversifies presentations (weights, forms and packaging) and tastes and introduces new characteristics such as “light” or “organic”. As they are required to be faithful to traditional recipes, PDOs are logically less involved in the process of innovation than non PDOs (the CVP is significantly lower for PDOs than for non PDOs). While PDOs can be unbranded goods processed by numerous small firms (for example in Comté), for several PDO cheeses (namely Roquefort or Camembert), brand concentration is very high: globally thus, the CR4 is not significantly different between the two products categories. Otherwise, in mass distribution, PDOs purchasers' mean income is significantly, but only slightly, higher than for standard products

(1131€/month against 979€). Lastly, the mean price difference between the two products categories is not significant.[8]

4. Method

Price elasticities are computed using the parameters of an Almost Ideal Demand System (AIDS, Deaton and Muelbauer, 1980). This model has been widely used in studies on food products, including complete demand systems and investigations on specific industries (see among many others, Nichèle and Robin, 1993; Shenggen, Wailes and Cramer, 1995; Moschini and Mielke, 1989; Bertail and Caillavet, 2008).

AIDS preserves the generality of other flexible demand models (translog and the Rotterdam) since the AIDS standard share equation (at time *t* and for *n* products):

$$w_{it} = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \log p_{it} + \beta_i \log(Y_t / P_t) + \varepsilon_{it}$$

can be read as a first-order approximation to the general unknown relation between product market share w_{it}, prices p_{it} and income Y_t (deflated by price index P_t). Moreover, as it does not start from some arbitrary preference system but from a specific class of preferences (PIGLOG), it allows exact aggregation across consumers. This makes it possible to represent demands as if they were the outcome of decisions by a rational representative consumer.

One limitation of demand models is that they cannot include a high number of alternatives. This limitation can be overcome thanks to the weak separability assumption. For staple food products, this assumption is acceptable: consumers buy them without balancing them much against other goods. Lastly, in demand models consumers may buy variable quantities. This assumption is more suitable than the unitary demand of choice models, more adapted to durable goods. Choices occurring upstream in the utility tree are taken into account through unconditional price elasticities (see §5). In the present study, we adopt a four-stages budgeting system.[9]

When estimating AIDS, three issues are of particular interest. First, most papers have followed Deaton and Muelbauer's suggestion to replace the translog index ($\log P_t = \alpha_0 + \sum_i \alpha_i \log p_{it} + \sum_i^n \sum_j^n \gamma_{ij} \log p_{it} \log p_{jt}$) by a linear approximation, the Stone index ($\log P_t = \sum_i w_i \log p_{it}$). Since then,

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[8]Additional costs induced by the use of raw milk instead of pasteurized milk are not the only source of price dispersion among cheeses. For example, the category of milk (cow or goat) also influences the costs.

[9] Consumers choose between non food and food, then between the different food items (including cheese), then again between grated cheese and natural cheese and finally within the set of 21 natural cheeses.

several objections have been raised against this practice.[10] The second issue is related to the semi-negativity of the Slutsky matrix which reflects concavity in prices of the expenditure function. The third issue concerns the endogeneity of expenditure and prices. Mass distribution is concentrated and enjoys some market power related to consumers' attachment to a small number of retailers located in their neighborhood. Prices may thus be adjusted to market shares variations (Dhar, Chavas and Gould, 2003). Expenditure is also potentially endogenous because income variations simultaneously impact the expenditure and the market shares.

We specify a model which takes into account the three points. We estimate the AIDS system with the non linear price index (translog), impose the concavity in prices through the Cholesky decomposition (Moschini, 1998, see appendix 1) and use the instrumental variables technique to deal with the problem of prices and expenditure endogeneity. The system of equations is thus both nonlinear in the variables and in the parameters. A Non Linear Three Stage Least Square estimation (N3SLS) is performed using SAS 9.2 ("proc model" command). Note that the 21st share equation is omitted in order to avoid singularity of the system.

To deal with the endogeneity problem, we collected another set of variables, available on a monthly basis, which may be used as instruments, related to:

• dairy sector: price of milk, price of Comte milk, milk production, industrial production index (IPI) of milk, price of soya oilcake...

• global economy: GNP, wages in food industry (IAA), non durable IPI, production price index (PPI) of diesel, PPI of plastic packaging, household food expenditure (cheese excluded)...

• supply: the Private Labels market share for each good

• weather: average monthly temperature in France for the period

At the last stage of the utility tree, the final set of instruments includes all the exogenous variables in the system and a set of 28 additional instruments (see table 10, in appendix 2). We first test the relevance of the instruments by checking their significance on the first-stage regression (for each equation). Then, we test the validity of the set of instruments computing a Sargan Overidentification Test. The null hypothesis of validity of the instruments is not rejected (p-value of 0.82).

To avoid the problems of too few purchases or even zero purchase for some cheese categories, the estimation is conducted for a representative consumer. Aggregation is performed on a monthly basis (4 weeks/month) leading to 78 observations. Moreover, for homogeneity reasons, the observation is limited to mass distribution stores (including the hard

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[10] Eales and Unnevehr (1988) have pointed out that budget shares appear on both sides of regression equations, producing simultaneity problems. Moschini (1995) found the Stone index is not invariant to changes in the units of measurement of prices. According to Buse (1994), the Stone index introduces a measurement error because prices are never perfectly collinear. Lafrance (2004) demonstrates that the linear model respects Slutsky symmetry under highly restrictive conditions which decrease the interest of the model.

discounters), which represent 93% of the cheese market. Specialized cheese retailers, where supply is biased in favor of PDOs and prices are significantly higher, are not accounted for. Households' heterogeneity (income, education) thus remains out of the scope of this study which focuses on consumers' mean attitude toward PDOs. Lastly, to control for changes in tastes, we introduce a monthly trend variable.

Monetary illusions are usually neutralized correcting income and prices by a price index of consumption goods. However, between 1998 and 2003, cheese prices have grown more rapidly than inflation, leading to increasing real cheese prices, thus correlated with the trend. To overcome this multicollinearity problem, we deflate all values by the mean price index of cheeses (National Institute of Statistics and Economic Studies).

5. Results

5.1 Direct price sensitivity

Table 4 presents the unconditional marshallian price-elasticities. Unconditional (or global) elasticities take into account all the previous budgeting decisions whereas conditional elasticities are related to one level of the multi-stage budgeting process. In the present case, conditional and unconditional elasticities are very similar. The reasons are basically that within the cheese subset, each product has a weak market share and, similarly, that the cheese market share within food expenditure and, further, the food market share within total expenditure are also small. For similar reasons marshallian and hicksian price-elasticities do not differ much. Indeed, the dispersion of the income elasticities (see below, section 5.3) is smoothed by the narrowness of market shares within the cheese subset: revenue-effects are thus negligible (formulas are given in appendix 4).

Table 4: Marshallian unconditional own-price elasticities

Products	***Own price elasticity***
1.PDO Camembert (CSC)	-3.72*
2.Non PDO Camembert (CSC)	-2.43***
3.PDO Brie (CSC)	-2.91***
4.Non PDO Brie (CSC)	-3.87***
5.Other PDO CSC	-3.56
6.Other Non-PDO CSC	-0.88**
7.Cantal (PDO)SPC	-2.22***
8.Other PDO SPC	-3.46***
9.Other non-PDO SPCs	-3.53***
10. Emmental (Non PDO)	-2.24***
11. Comté (PDO)	-2.08***
12.Other PDO HC	-2.31**
13.Other Non PDO HC	-0.99*
14.PDO BC	-2.28**
15.Non PDO BC	-2.10*
16. Roquefort (PDO) BC	-4.73***
17.Munster (PDO)OSC	-2.24***
18.Other PDO OSC	-3.24***
19.Other non-PDO OSC	-2.06**
20.Spread cheeses and fresh cheeses	-1.12***
21.Goat cheeses	-1.35*

***, ** and * indicate the significance of the estimated elasticity at the 1%, 5% and 10% levels.

All the elasticities have the right sign and only one is not statistically significant (*Other PDO Soft Cheese*). Residual autocorrelation has been tested for each of the 20 equations of the system. The null assumption is not rejected in 19 cases out of 20 at a 5% significance level (Ljung Box test, see table 11 in appendix 3). The trend is statistically significant in 8 cases out 21 (see table 12 in appendix 3). The β_i and γ_{ij} coefficients measuring the sensitivities of the market shares to income and price variations are given in appendix 3 (tables 13 and 14).

With a mean price elasticity of -2.55 (median -2.29) computed over the 20 statistically significant observations, cheeses appear globally elastic to price. This result, which contrasts with previous papers, may be related to relaxing the exogeneity assumption of prices and income.[11] In our study, the exogeneity assumption would have underestimated the mean and median elasticities by respectively 66% and 94% (see table 4), an evaluation which is coherent with other observations. Thus, according to Dar, Chavas and Gould (2002), controlling for endogeneity in an AIDS increases the magnitude of the direct price elasticities by 90%. Villas-Boas and Winer (1999) record a 50% increase in own-price elasticities estimated using a choice model where prices are instrumented. Bijmolt, Heerde and Pieters (2005) in their meta-analysis

[11] Supposing prices and income exogenous to the market shares, Bouamra et al. (2008) find for six aggregates of French cheeses own-price elasticities ranging from -1.22 to -0.27.

covering 1851 price elasticities find that the exogeneity assumption underestimates the elasticities by 50%.[12]

Other methodological choices also influence the own-price elasticities magnitude, but not so greatly. Table 5 compares the results (mean and median elasticities) of 5 models relying on different assumptions. Imposing the concavity of the expenditure function increases the elasticities magnitude by half a point (model 1 to model 2, table 5). Conversely, using the translog index (instead of the linear index) has no impact (model 2 to model 3). Introducing a trend variable decreases the apparent price sensitivity (model 4 to model 5). This finding is also in accordance with Bijmolt, Heerde and Pieters (2005) who highlight that in the long run, sales elasticities increase in magnitude by 0.04 per year.[13] Introducing a trend variable captures part of this long term movement.

Table 5: Comparison of price elasticities according to 5 different methodological choices*

Models	*Mean*	*Median*
Model 1: Linear AIDS (LAIDS) basic model	-1.26	-1.40
Model 2: LAIDS basic model + concavity (Cholesky)	-1.74	-1.60
Model 3: AIDS model + Cholesky	-1.74	-1.60
Model 4: AIDS model + Cholesky + Instruments	-2.89	-3.10
Model 5: AIDS model + Cholesky + Instruments + trend	-2.55	-2.29

* Comparison takes into account the 21 elasticities of each model

While methodological choices have a strong impact on the level of the elasticities, they do not influence the ranking as much. Spearman coefficients of rank correlation between the elasticities related to the five models in table 5 are presented in table 6. Most coefficients are high (over 60%); the main sources of divergence are the trend variable (model 5 versus model 4) and the instrumentation of income and prices (model 4 versus model 3).

[12] Endogeneity can a priori bias own-price elasticities in the two directions (up and down), depending on the sign of the price-error term correlation. Resuming arguments from different papers, Bijmolt and al. (2005) provide some understanding of this feature: “If a manager decides to decrease price for situations in which some factor known to him/ her but unknown to the researcher causes a positive demand shock, the price elasticity magnitude gets inflated if price is assumed to be exogenous. On the other hand, if at a positive demand shock, a manager increases price (e.g., to reap profits), the price elasticity estimate is biased towards zero under the exogeneity assumption”.

[13] This feature is referred to a more intensive use of promotions instead of advertising which makes consumers more sensitive to price.

Table 6: Spearman correlations between price elasticities computed from 5 models

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*
Model 1: LAIDS	—				
Model 2: LAIDS + Cholesky	0.9019	—			
Model 3: AIDS + Cholesky	0.9096	0.9987	—		
Model 4: Model 3 + Instruments	0.7690	0.8590	0.8692	—	
Model 5: Model 4 + trend	0.4824	0.6354	0.6414	0.7059	—

Our results do not confirm the widespread belief that PDOs benefit from greater loyalty among consumers. Comparing the mean own-price elasticity of the two product categories reveals that PDOs are in fact more price sensitive than standard products (resp. -2.95 and -2.06, the means difference being statistically significant at a confidence level of 10%). For 4 products which are only non PDO cheeses, the own-price elasticity is around -1. Nine products whose own-price elasticity is around -2 split up equally into 5 PDOs and 4 non PDOs. The 7 remaining very price elastic cheeses (elasticity close to or lower than -3, one observation being lower than -4) are 5 PDOs and 2 standards products. Table 7 summarizes the distribution. In table 8, the 21 cheeses are sorted according to their price elasticity.

Table 7: Distribution of the own-price elasticities

	Total number of products	*PDOs*	*Standard products*
Elasticities around -1 (from -0.88 to -1.35)	4	0	4
Elasticities around -2 (from -2.06 to -2.43)	9	5	4
Elasticities around or lower than -3 (from -2.91 to -4.47)	7	5	2
Total	20	10	10

Table 8: Sorted own-price elasticities of cheeses

Products	***Own-price elasticity***	***PDO***
16. Roquefort (PDO) BC	-4.73***	1
4. Non PDO Brie (CSC)	-3.87***	0
1. PDO Camembert (CSC)	-3.72*	1
5. Other PDO CSC	-3.56	1
9. Other non-PDO SPC	-3.53***	0
8. Other PDO SPC	-3.46***	1
18.Other PDO OSC	-3.24***	1
3. PDO Brie (CSC)	-2.91***	1
2. Non PDO Camembert (CSC)	-2.43***	0
14. PDO BC	-2.28**	1
10. Emmental (Non PDO)HC	-2.24***	0
17. Munster (PDO)OSC	-2.24***	1
12. Other PDO HC	-2.31**	1
7. Cantal (PDO)SPC	-2.22***	1
15. Non PDO BC	-2.10*	0
11. Comté (PDO) HC	-2.08***	1
19. Other Non-PDO OSC	-2.06**	0
21. Goat cheeses	-1.35*	0
20. Spread cheeses and fresh cheeses	-1.12***	0
13. Other non PDO HCs	-0.99*	0
6. Other non-PDO CSC	-0.88**	0

***, ** and * indicate the significance of the estimated elasticity at the 1%, 5% and 10% levels.

Several reasons may lie behind this counterintuitive result. In particular, consumers have now become more attracted to products that are mild, safe and easy to keep. This feature works against raw milk cheeses, which have been marginalized in the shopping baskets. Becoming more occasional, PDOs purchases became also more dependent on prices. Otherwise, consumers are generally sensitive to product innovations. The PDO status does not favor the innovation process and this increases the marginalization of PDO cheeses in terms of household's loyalty. Moreover, product differentiation makes it more difficult for consumers to compare prices, which lowers the price elasticities. Little-differentiated goods like PDO cheeses should thus exhibit higher price elasticities. It should be noted that the four least elastic products (all non PDOs) are also those with the highest price variation coefficients.[14]

[14] Single regressions of price elasticities on purchase frequency or price coefficient of variation are statistically significant and positive: each variable lowers the price elasticity magnitude. However, multicollinearity (the two variables are correlated with each other and with the dummy PDO, itself correlated with the own-price elasticities) makes it impossible to disentangle the different effects. In other terms, our database is constructed to compare the own-price elasticities of two categories of products; to assess the determinants of the elasticities, larger samples of observations are required.

5.2 Cross-price elasticities

Only 66 out of the 420 cross-price elasticities (16%) are statistically significant (results are given in table 15, appendix 3).[15] Moreover, half of them refer to complementarities, with consumers buying several products during the same purchasing act. So substitutability is not a strong feature, which indicates that on the French cheese market, products remain specific. When competition occurs between brands selling standardized goods, cross-price elasticities are more systematically significant (concerning the American cheese market, see Cotterill and Samson, 2002 and Arnade, Gopinath and Pick, 2007). All goods have however one or more strong substitutes which, surprisingly, are not related to any basic element such as the process or the name of the product (PDO Camembert /standard Camembert). This last feature underlines the fact that PDOs and non-PDOs are perceived as separate goods, even if they go by the same name.

5.3 Sensitivity to income

Unconditional income elasticities are homothetic transformations of conditional elasticities, the coefficient of proportionality being the product of the expenditure elasticities at the upper stages of the utility tree (formula are given in appendix 4). Here, this product is close to 1 (0.88): the income elasticities thus reflect the cheese expenditure elasticities.

14 out of 21 income elasticities (7 PDOs and 7 standard products) are statistically significant (table 9). Across these 14 values, the mean income elasticity is 1.67 and the median is 1.32: cheeses are thus globally income-elastic. Moreover, PDOs are more sensitive to income and expenditure variations than standard products: 5 out of 7 elasticities related to PDOs are above the median against 2 out of 7 with standard products and the mean values corresponding to the two sub-groups are respectively 2.25 and 1.10 (their difference is statistically significant at a confidence level of 10%, see table 9). PDOs purchases are thus more conditional than standard products both on prices and on income variations, confirming their status of secondary source of provision.

[15] For a six aggregates choice set, Bouamra et al. (2008) find 25% of significant cross-price elasticities.

Table 9: Unconditional income elasticities

Products	*Income elasticity*
1.PDO Camembert (CSC)	0.74
2.Non PDO Camembert (CSC)	0.78***
3.PDO Brie (CSC)	0.69
4. Non PDO Brie (CSC)	1.07***
5.Other PDO CSC	1.89
6.Other Non-PDO CSC	0.32***
7.Cantal (PDO)SPC	1.58***
8.Other PDO SPC	3.08***
9.Other non-PDO SPCs	1.85***
10. Emmental (Non PDO)	0.66***
11. Comté (PDO)	0.91***
12.Other PDO HC	2.37***
13.Other Non PDO HC	0.32
14. PDO BC	1.01**
15. Non PDO BC	0.80**
16. Roquefort (PDO) BC	1.58***
17. Munster (PDO)OSC	0.70
18.Other PDO OSC	5.21***
19.Other Non-PDO OSC	2.22**
20.Spread cheeses and fresh cheeses	-0.18
21.Goat cheeses	0.06

***, ** and * indicate the significance of the estimated elasticity at the 1%, 5% and 10% levels

6. Conclusion

PDOs are considered as upmarket products because they are based on tradition and convey information about their geographical origin. Otherwise, the conditions of production, especially the existence of limited geographical areas, lead to suspicions of monopoly power. Quality and monopoly power should translate into higher own-price elasticities. The aim of this paper was to check for this. The cheese market is a good example for this kind of investigation because PDOs cheeses are numerous and have a globally significant market share. Relying on 21 products including eleven PDOs and ten standard products, this study provides, to our knowledge, the first systematic investigation on this matter.

The results are counterintuitive. PDOs are as price elastic as or more price elastic than stadard products. So, globally, consumers are not more but less loyal to PDOs than to standard products. Like Bonnet and Simioni (2001) but for a large sample of products, this paper challenges the widespread belief that, in the cheese sector and for most consumers, PDOs represents the high quality. This research also has political implications since it shows that PDO cheese suppliers cannot decide on price increases without suffering large reductions in demand. This finding should be considered by competition authorities.

We found little price substitutability between products. However, PDO and non PDO cheeses are branded goods and there is competition between these brands too. To capture substitutions more accurately, further research could introduce one more stage in the utility tree, allowing consumers to choose between brands proposing the same product. Otherwise, the aim of this study was not to highlight the determinants of the price elasticities and the probable role of consumers’ tastes, purchasing habits and product innovation must be confirmed by further investigation. Extending the model to brand competition may also provide more observations to assess the determinants of consumers' attitude towards GIs.

Appendix 1: The estimated system

We follow Moschini (1998) to deal with the concavity property in our demand system. To satisfy the concavity property, the matrix $\theta = [\theta_{ij}]$ must be negative semi-definite. One way to impose it is to reparameterize θ with the Cholesky decomposition. Then, a necessary and sufficient condition for the matrix θ to be negative semi-definite, is that it can be written as $\theta = -T'T$ where $T=[\tau_{ij}]$ is an (n-1)*(n-1) upper triangular matrix (in other words: $\tau_{ij}=0$ for i>j). Example if N=5, T is 4*4:

$$T = \begin{pmatrix} \tau_{11} & \tau_{12} & \tau_{13} & \tau_{14} \\ 0 & \tau_{22} & \tau_{23} & \tau_{24} \\ 0 & 0 & \tau_{33} & \tau_{34} \\ 0 & 0 & 0 & \tau_{44} \end{pmatrix}$$

And

$$\theta = -\begin{pmatrix} \tau_{11}^2 & \tau_{11}\tau_{12} & \tau_{11}\tau_{13} & \tau_{11}\tau_{14} \\ & \tau_{12}^2+\tau_{22}^2 & \tau_{12}\tau_{13}+\tau_{22}\tau_{23} & \tau_{12}\tau_{14}+\tau_{22}\tau_{24} \\ & & \tau_{13}^2+\tau_{23}^2+\tau_{33}^2 & \tau_{13}\tau_{14}+\tau_{23}\tau_{24}+\tau_{33}\tau_{34} \\ & (symmetric) & & \tau_{14}^2+\tau_{24}^2+\tau_{34}^2+\tau_{44}^2 \end{pmatrix}$$

The locally concave system can be written as:

$$\begin{cases} w_i = \alpha_i + \alpha_i log(\frac{p_i}{P^\alpha}) - \sum_{s=1}^{i} \tau_{si} \cdot log(P_s^\tau) + \beta_i \cdot log(\frac{x}{P}) & , i = 1,2,\ldots,n-1 \\ with \quad log(P^\alpha) = \sum_{i=1}^{n} \alpha_i \cdot log p_i & \\ and \quad log(P_s^\tau) = \sum_{j=s}^{n-1} \tau_{sj} \cdot log(\frac{p_j}{p_n}) & , s = 1,2,\ldots,n-1 \\ and \quad log(P) = log(P^\alpha) - \frac{1}{2}(log P^\alpha)^2 + \frac{1}{2}\sum_{i=1}^{n} \alpha_i (log p_i)^2 + \frac{1}{2}\sum_{i=1}^{n-1}\sum_{j=1}^{n-1} \theta_{ij} \cdot log(\frac{p_i}{p_n}) log(\frac{p_j}{p_n}) & \end{cases}$$

To avoid estimation problems (due to too many parameters), Moschini (1998) suggests estimating a restricted model by taking a substitution matrix of rank K<(n-1)[16]. Moreover, adding a monthly trend variable consists in replacing α_i by a $\alpha_i' = \alpha_i + m_i$.
Thus, the system becomes:

[16] Moschini suggests that K does not exceed the number of negative eigenvalues of the unrestricted model. In our case, we have K=13.

$$
\begin{cases}
w_i = (\alpha_i + m_i \cdot Trend) + (\alpha_i + m_i \cdot Trend) \cdot log(\frac{p_i}{P^{\alpha}}) - \sum_{\substack{s=1 \\ s \leq K}}^{i} \tau_{si} \cdot log(P_s^{\tau}) + \beta_i \cdot log\frac{x}{P} \quad , i = 1, 2, \ldots, n-1 \\
with \quad log(P^{\alpha}) = \sum_{i=1}^{n} (\alpha_i + m_i \cdot Trend) \cdot log p_i \\
and \quad log(P_s^{\tau}) = \sum_{j=s}^{n-1} \tau_{sj} \cdot log(\frac{p_j}{p_n}), \ s = 1, 2, \ldots, n-1 \\
and \qquad log(P) = log(P^{\alpha}) - \frac{1}{2}(log P^{\alpha})^2 + \frac{1}{2}\sum_{i=1}^{n} (\alpha_i + m_i \cdot Trend) \cdot (log p_i)^2 - \frac{1}{2}\sum_{s=1}^{n-1} (log(P_s^{\tau}))^2
\end{cases}
$$

Once we have the estimated coefficients τ_{ij}, we can first recover the θ_{ij} and then recover the γ_{ij} using the substitution term of the Slutsky matrix:
$\theta_{ij} = \gamma_{ij} + \alpha_i \alpha_j - \delta_{ij} \alpha_i$ with $\delta_{ij}=1$ for i=j and 0 for $i \neq j$. Finally, we can easily compute the standard elasticities (see formula in appendix 4).

Appendix 2: Instrumental variables at the last stage of the budgeting system

Table 10: Instruments used at the last stage of the utility tree

Instruments	Source
Standard milk price	National Institute of Statistics and Economic Studies
Price index of diesel	id
Price index of plastic packaging	id
Price of soybean cakes	id
Comté cheese wholesale price	id
Wage in the food industry	id
Price index of dairy products	id
Price index of non durable goods	id
Produced Quantity of processed oak milk	Ministry of Agriculture (Agreste)
Quantity of conditioned sterilized milk	id
Quantity of flavored milk	id
Food expenditure (cheese excluded)	Kantar Worldpanel
% Private labels (PDO soft cheeses)	id
% Private labels (standard soft pressed cheeses)	id
% Private labels (PDO soft cheeses "à croûte lavée")	id
% Private labels (standard soft cheeses "à croûte lavée")	id
% Private labels (Reblochon and other similar PDOs)	id
% Private labels (PDO blue cheeses)	id
% Private labels (PDO Brie)	id
% Private labels (Pasteurized Camembert)	id
% Private labels (Cantal)	id
% Private labels (Comté)	id
% Private labels (Emmental)	id
% Private labels (Munster)	id
% Private labels (Other standard hard cheeses)	id
% Private labels (Roquefort)	id
% Private labels (Spread cheeses and "fromages frais")	id
Average temperature in France	INRA (Agroclim)

Appendix 3: Some estimation results of the last stage of the budgeting system

Table 11: Ljung Box test for residual autocorrelation
(for each of the 20 equations of the estimated demand system)

Equation	P-value
1	0.1438729
2	0.0705631
3	0.2352641
4	0.9937290
5	0.9392385
6	0.0343230
7	0.8677286
8	0.7137678
9	0.7630428
10	0.2004335
11	0.6734862
12	0.6126476
13	0.7584857
14	0.1274372
15	0.0699778
16	0.1428842
17	0.1498244
18	0.3453170
19	0.0861219
20	0.0960614

The null hypothesis corresponds to no autocorrelation.

Table 12: Sign of the trend coefficients (only when significant)

m_3	-
m_6	-
m_9	+
m_{10}	-
m_{13}	-
m_{18}	+
m_{19}	-
m_{20}	+
m_{21}	+

Table 13: Estimated βi for each of the i[th] estimated equation of the last stage of the budgeting system

β_1	-0.002
β_2	-0.009
β_3	-0.002
β_4	0.004
β_5	0.004
β_6	-0.083***
β_7	0.011*
β_8	0.094***
β_9	0.159***
β_{10}	-0.023
β_{11}	0.001
β_{12}	0.026**
β_{13}	-0.011
β_{14}	0.002
β_{15}	-0.003
β_{16}	0.025**
β_{17}	-0.002
β_{18}	0.063***
β_{19}	0.029***
β_{20}	-0.207***

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 14: Matrix of the estimated γ_{ij} coefficient of each of the i^{th} estimated equation of the last stage of the budgeting system

j

i	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	-.035	-.035	.001	.004	.002	-.004	-.02*	-.028	.009	.058	-.024	.011	-.013	.01	.019	.005	.007	.009	0	.029	-.007
2	.	-.12*	.036**	-.042	.003	-.039	-.021	-.049	.095**	.058	-.009	.033	-.012	-.017	.045	.082**	.001	.046*	.012	-.08**	.014
3	.	.	-.016**	.014*	-.004	.018	.001	.003	.02	.013	-.001	-.015**	.002	.005	-.028**	-.047***	-.002	-.015*	-.013	.017	.012
4	.	.	.	-.06***	0	.012	.011	.012	.028	-.055*	.011	-.002	.003	-.018	.024	.032	-.007	.016	.014	-.015	.016
5	.	.	.	.	-.009	-.005	.001	-.002	.018	.02	-.003	-.007	.005	-.011	.002	-.007	-.002	-.007	-.008	.004	.009
6	.	.	.	.	.	0	-.019	-.021	-.014	.038	.001	.016	-.012	.007	.034	.053	-.018	-.002	-.012	.013	-.046
7	.	.	.	.	.	.	-.017	-.024	.013	.04*	.016	-.005	0	.008	.012	.006	-.002	-.004	-.001	-.006	.011
8	.	.	.	.	.	.	.	-.089*	.065**	.087*	.005	.003	-.017	.023	.019	.019	.01	.001	-.012	-.007	.002
9	.	.	.	.	.	.	.	.	-.359***	-.054	.032	.054**	-.004	.004	-.012	.036	-.024**	.02	.049**	.027	-.003
10	.	.	.	.	.	.	.	.	.	-.122	.008	-.014	.002	-.008	-.022	-.009	.003	-.012	.035	-.053	-.013
11	.	.	.	.	.	.	.	.	.	.	-.053	.018	-.004	-.016	.017	.015	-.001	.001	-.011	.021	-.024
12	.	.	.	.	.	.	.	.	.	.	.	-.02	.013	-.001	-.012	-.029*	.005	-.015	-.012	-.026	.005
13	.	.	.	.	.	.	.	.	.	.	.	.	0	.013*	0	-.006	.007	-.003	.007	.023	-.004
14	.	.	.	.	.	.	.	.	.	.	.	.	.	-.017	.012	.016	-.007	.001	-.006	-.022	.021
15	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-.032	-.077**	0	-.012	.003	.004	.005
16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-.118***	.006	-.04**	-.013	.063**	.012
17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-.013**	-.002	.007	.019*	.014
18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-.027*	-.006	.027	.023
19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-.02	.005	-.019
20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	-.049	.007
21	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

Note that to make the matrix easily readable, we do not write all the γ_{ij} coefficients (for i>j and $\gamma_{21,21}$). They can be easily recovered taking into account the homogeneity and symmetry restrictions ($\sum_j \gamma_{ij} = \sum_i \gamma_{ij}=0$ and $\gamma_{ij} = \gamma_{ji}$).

Table 15: Matrix of the estimated unconditional and uncompensated price elasticities between goods of the last stage of the budgeting system (taking into account the whole utility tree)

i \ j	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	**-3.715***	-2.618	.116	.313	.148	-.163	-1.542*	-2.127	.757	4.516	-1.79	.876	-.986	.818	1.46	.382	.521	.712	.04	2.404	-.443
2	-.421	**-2.432*****	0.447**	-.511	.037	-.368	-.257	-.618	1.222***	.789	-.086	.415	-.139	-.205	.576	1.033**	.021	0.562*	.149	-0.810*	.251
3	.175	4.220**	**-2.913*****	1.703*	-.448	2.165	.112	.308	2.43	1.543	-.068	-1.766**	.264	.583	-3.260**	-5.491***	-.225	-1.719*	-1.532	2.171	1.447
4	.195	-1.98	0.700*	**-3.871*****	-.002	.699	.528	.569	1.367*	-2.586*	.575	-.115	.168	-.857	1.188	1.549	-.324	.737	.693	-.554	.856
5	.539	.842	-1.081	-.009	**-3.562**	-1.301	.231	-.553	4.907	5.76	-.831	-1.898	1.331	-3.05	.616	-1.958	-.574	-1.97	-2.189	1.247	2.679
6	-.016	-.227	.142	.112	-.035	**-0.877****	-.133	-.144	-.005	.372	.046	.136	-.076	.068	.283	.43	-.132	-.01	-.078	.279	-.273
7	-1.390*	-1.443	.067	.765	.057	-1.208	**-2.217*****	-1.695	.819	2.815*	1.151	-.393	-.011	.587	.862	.406	-.129	-.327	-.052	-.196	.845
8	-.724	-1.31	.069	.31	-.051	-.496	-.64	**-3.459*****	1.434*	2.280*	.117	.043	-.433	.591	.491	.462	.273	-.072	-.37	.021	.12
9	.066	0.668***	.141	0.193*	.118	-.007	.08	0.371*	**-3.531*****	-.328	.228	0.349**	-.012	.028	-.074	.231	-0.160**	.091	0.311**	.376	.054
10	.633	.689	.143	-0.582*	.221	.523	0.438*	0.941*	-.521	**-2.245*****	.124	-.152	.039	-.078	-.215	-.084	.044	-.138	.384	-.394	-.06
11	-.485	-.146	-.012	.25	-.062	.126	.346	.094	.706	.239	**-2.076*****	.368	-.064	-.32	.368	.318	-.013	.001	-.238	.623	-.42
12	.722	2.125	-0.960**	-.152	-.428	1.126	-.359	.104	3.272**	-.895	1.118	**-2.314****	.84	-.044	-.788	-1.864*	.333	-1.019	-.794	-1.431	.375
13	-.731	-.641	.129	.2	.27	-.568	-.009	-.943	-.096	.209	-.175	.756	**-0.991***	0.764*	.003	-.299	.416	-.169	.39	1.484	-.143
14	.803	-1.252	.377	-1.351	-.819	.668	.639	1.707	.315	-.545	-1.158	-.052	1.012*	**-2.281****	.96	1.186	-.491	.049	-.421	-1.487	1.7
15	.657	1.616	-0.968**	.859	.076	1.282	.431	.651	-.375	-.691	.61	-.431	.002	.44	**-2.099***	-2.648**	-.002	-.422	.109	.305	.249
16	.157	2.637**	-1.486***	1.02	-.22	1.771	.185	.558	1.078	-.246	.481	-0.928*	-.166	.496	-2.413**	**-4.734*****	.194	-1.290**	-.418	2.186**	.452
17	.65	.164	-.185	-.65	-.196	-1.663	-.179	1.005	-2.275**	.393	-.06	.506	.701	-.625	-.004	.59	**-2.242*****	-.244	.647	1.980*	1.383
18	.712	3.498*	-1.135*	1.183	-.539	-.103	-.364	-.214	1.03	-.992	.002	-1.239	-.229	.049	-.939	-3.148**	-.196	**-3.241*****	-.537	2.317	1.812
19	.027	.62	-.675	.743	-.4	-.524	-.039	-.726	2.365**	1.828	-.586	-.644	.351	-.287	.161	-.681	.346	-.358	**-2.064****	.476	-.902
20	.182	-0.380*	.108	-.067	.026	.212	-.016	.006	.326	-.211	.174	-.131	.151	-.114	.051	0.403**	0.120*	.176	.054	**-1.115*****	.124
21	-.071	.25	.152	.219	.117	-.437	.15	.057	.101	-.068	-.247	.073	-.031	.277	.088	.176	.177	.29	-.215	.262	**-1.349***

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix 4. Formula of conditional and unconditional Marshallian (uncompensated) elasticities

Denoting by i and j two commodities belonging to the group of commodities r, following Green and Alston (1990) and Alston et al. (1994) the conditional elasticities are defined as:

- price elasticity for good *i* with respect to good *j*: $e_{(r)ij} = \frac{\gamma_{ij}}{w_i} - \beta_i \frac{w_j}{w_i} - \delta_{ij}$,
- expenditure elasticity for good *i*: $E_{(r)i} = 1 + \frac{\beta_i}{w_i}$,

  where δ_{ij} is the Kronecker delta, $\delta_{ij} = \begin{cases} 1 \; for \; i = j \\ 0 \; for \; i \neq j \end{cases}$.

To compute unconditional elasticities we use the method suggested by Carpentier and Guyomard (2001) that corrects Edgerton (1997). Carpentier and Guyomard (2001) provide the expression of price elasticities for a two-stage budgeting, Bouamra and al. (2008) extend the formula up to a four stages case.

For a four-stage budgeting, denoting by *i* and *j* two commodities, belonging, respectively, to the sub-groups of commodities *r* and *s* that belong, respectively, to the sub-groups *a* and *b*, belonging, respectively, to the groups φ and χ[17], unconditional price elasticities at the 4th stage are defined as :

$$
\begin{aligned}
e_{ij} = {} & \delta_{rs} \times e_{(\varphi)(a)(r)ij} + w_{(\chi)(b)(s)j} \times \left[\frac{\delta_{rs}}{E_{(\chi)(b)(s)j}} + e_{(r)(s)} \right] \times E_{(\varphi)(a)(r)i} \times E_{(\chi)(b)(s)j} + w_{(\chi)(b)(s)j} \times w_{(\chi)(b)s} \times E_{(\varphi)(a)r} \times E_{(\varphi)(a)(r)i} \times (E_{(\chi)(b)(s)j} - 1) \\
& + w_{(\chi)(b)(s)(j)} \times w_{(\chi)(b)s} \times \left[\frac{\delta_{ab}}{E_{(\chi)(b)(s)j} \times E_{(\chi)(b)s}} + e_{(a)(b)} \right] \times E_{(\varphi)(a)(r)i} \times E_{(\varphi)(a)r} \times E_{(\chi)(b)(s)j} \times E_{(\chi)(b)s} \\
& + w_{(\chi)(b)(s)(j)} \times w_{(\chi)(b)s} \times w_{(\chi)b} \times E_{(\varphi)(a)(r)i} \times E_{(\varphi)(a)r} \times E_a \times (E_{(\chi)(b)(s)j} \times E_{(\chi)(b)s} - 1) \\
& + w_{(\chi)(b)(s)j} \times w_{(\chi)(b)s} \times w_{(\chi)b} \times \left[\frac{\delta_{\varphi\chi}}{E_{(\chi)(b)(s)j} \times E_{(\chi)(b)s} \times E_{(\chi)b}} + e_{(\varphi)(\chi)} \right] \times E_{(\varphi)(a)(r)i} \times E_{(\varphi)(a)r} \times E_{(\varphi)a} \times E_{(\chi)(b)(s)j} \times E_{(\chi)(b)s} \times E_{(\chi)b} \\
& + w_{(\chi)(b)(s)j} \times w_{(\chi)(b)s} \times w_{(\chi)b} \times w_\chi \times E_\varphi \times E_{(\varphi)(a)(r)i} \times E_{(\varphi)(a)r} \times E_{(\varphi)a} \times (E_{(\chi)(b)(s)j} \times E_{(\chi)(b)s} \times E_{(\chi)b} - 1)
\end{aligned}
$$

where:

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[17] Note that, in our case of interest, $\varphi = \chi$ = food *;* *a* = *b* = cheese *;* *r* = *s* = natural cheese *;* and *i* and *j* belong to the 21 cheese products categories.

- Conditionnal price elasticities are given by :
  $e_{(\varphi)(a)(r)ij}$ is the conditional price elasticity of good i with respect to good *j*,
  $e_{(r)(s)}$ is the conditional price elasticity of sub-group *r* with respect to sub-group *s*,
  $e_{(a)(b)}$ is the price elasticity of sub-group *a* w.r.t. sub-group *b*,
  $e_{(\varphi)(\chi)}$ is the price elasticity of group φ w.r.t. group χ.
- Conditionnal expenditure elasticities are given by :
  $E_{(\chi)(b)(s)j}$ is the conditional expenditure elasticity of good *j* (conditional w.r.t. expenditures of sub-group *s*),
  $E_{(\varphi)(a)(r)i}$ is the conditional expenditure elasticity of good *i* (conditional w.r.t. expenditures of sub-group *r*),
  $E_{(\chi)(b)s}$ is the conditional expenditure elasticity of sub-group *s* (conditional w.r.t. expenditures of sub-group *b*),
  $E_{(\varphi)(a)r}$ is the conditional expenditure elasticity of sub-group *r* (conditional w.r.t. expenditures of sub-group *a*),
  $E_{(\varphi)a}$ is the expenditure elasticity of sub-group *a* (conditional w.r.t. expenditures of group φ),
  $E_{(\chi)b}$ is the expenditure elasticity of sub-group *b* (conditional w.r.t. expenditures of group χ),
  E_{φ} is the expenditure elasticity of group φ.
- Budget shares are given by :
  $w_{(\chi)(b)(s)j}$ is the budget share of good *j* in commodity sub-group *s*,
  $w_{(\chi)(b)s}$ is the budget share of sub-group *s* in sub-group *b*,
  $w_{(\chi)b}$ is the budget share of sub-group *b* in group χ,
  w_{χ} is the budget share of group χ.
- $\delta_{\varphi\chi}$, δ_{ab} , and δ_{rs} are Kronecker deltas.

For the same stage, the unconditional expenditure elasticity for good *i* that belongs to the sub-group *r*, belonging to the sub-group *a*, that belongs to group φ, is given by $E_i = E_{(\varphi)(a)(r)i} * E_{(\varphi)(a)(r)} * E_{(\varphi)(a)} * E_{(\varphi)}$ where

$E_{(\varphi)(a)(r)i}$ is the conditional expenditure elasticity of good i (conditional w.r.t. expenditures of sub-group *r*),
$E_{(\varphi)(a)(r)}$ is the conditional expenditure elasticity of sub-group r (conditional w.r.t. expenditures of sub-group *a*),

$E_{(\varphi)(a)}$ is the conditional expenditure elasticity of sub-group a (conditional w.r.t. expenditures of group φ),
and $E_{(\varphi)}$ is the expenditure elasticity of group φ.

Finally, in order to estimate the standard errors of all the estimated elasticities, we use the delta-method.

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