Effects of Traceability on the Italian Fresh Vegetables Market: A Demand System Simulation[1]

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1 Introduction

Traceability can serve various purposes in the food sector, including that of chain quality control. However, the aspects that seem to be most frequently required of traceability are those related to food safety. Nevertheless, traceability systems development has recently shifted its focus from the major aspects of food safety to a price premium search approach. Although such an approach often appears to lie behind production strategies, there is no technical or theoretical evidence to support it: traceability systems do not guarantee, per se, quality. On the other hand, a rigorous traceability system that pursues multiple objectives involves costly procedures that are very likely to feed all the way up to the consumer side.

The mainstream literature is rich in technical and economic studies on traceability. Nevertheless, little has been written on the effects of traceability costs on quantity demanded. While numerous studies show a higher consumer willingness to pay for certified products, it is not clear in what way and to what extent price increases affect the market.

The objective of the present study is to estimate the effect of the introduction of a potentially rigorous traceability procedure on the Italian fresh vegetables market, with particular attention to new potatoes. In order to do so, a system of demand functions was built on real household consumption data (3,000 observations) statistically representative of the Italian population of households. Own- and cross-price elasticities, as well as other relevant measures of market variables, were estimated by means of a demand system for a large set of fresh vegetables (potatoes split into early and late, salad, pulses, eggplants and peppers, asparagus, spinach, tomatoes, carrots, fennel, IV vegetables and others). In the demand system we also explicitly implemented the introduction of a new traceability procedure which is now under study at the University of Naples Federico II in a project financed by the Italian Ministry of Agricultural and Forestry Policy. This system allows a fresh vegetable product to be unequivocally traced by means of molecular and spectrometer techniques. Although the study concerns new potato, results can be easily applied to other fresh vegetables. Indeed, while our demand system estimation focused on new potato, since we implemented a system of equations representing a large set of fresh vegetables, a larger amount of information for a wider set of products was obtained. From an empirical point of view, according to the established consensus, demand system estimates based on household cross section data can be cumbersome on several grounds. The two main 'dangers' are

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violation of theoretical regularity restrictions (Barnett and Serletis, 2008) and possible sample selection bias due to only a fraction of the population that has non-zero consumption for the items under study (new potatoes are consumed by 51.7% of Italian households). To solve these and also other issues a two-step censored demand system (Shonkwiler and Yen, 1999) based on the well-known LA-AIDS was used.

2 Background on traceability

Traceability may be considered as a product differentiation system and is commonly used by the food industry. Once contamination has been detected, traceability systems allow the source of a product to be identified, thereby enabling the situation to be remedied and limiting costs to total or partial product withdrawal from the market.

Traceability has to be primarily viewed as a means to enhance safety in the food chain. The recent development of traceability systems for production and market sectors has sought to translate attention from the primary concept of food safety into the search for a consumer price premium. This approach appears to be becoming increasingly established in product strategies even if there seems to be no theoretical motivation in support: traceability systems do not guarantee pursuance of product quality; rather, they 'simply' trace it 'from the field to the fork'.

The International Organization for Standardization (ISO 9001:2000) defines traceability as the ability to identify and trace the history, distribution, location, and application of products, parts, and materials. The Codex has adopted this definition to determine guidelines and standards for traceability (Codex Alimentarius Commission, 2001). The European Union has defined traceability with particular reference to GMO products or their derivatives.

The most significant motivation was to be ready for any undesired eventuality at any stage of the chain for withdrawing the products causing a potential risk for consumers. In this case, traceability ensures the timely intervention of product withdrawal, as well as the reduction in costs in implementing withdrawal, being able to focus on withdrawing one or more brands, rather than withdrawing from the market an entire product category.

The economic literature has studied the phenomenon and functioning of traceability in various respects. Although traceability arose for the main purpose of ensuring food safety, Dickinson and Bailey (2002) showed, in an experimental market study, that consumers are willing to pay a price premium for those products that clearly show they are traceable.

Various traceability systems have been established in Europe and North America. In Canada, for example, traceability has been developed jointly with an integrated quality system so as to give foreign markets assurances, especially with regard to meat. In this case, it should be noted that the prime resistance came from producers insofar as they resented government interference on the issue of regulation, and hence violation of the freedom to make entrepreneurial decisions, of their own business. Moreover, the incentives derived from any price premium are unlikely to affect the production phase, tending to be distributed among the various actors in the chain in the post-production phase.

Since January 1st 2005 it has become mandatory for all food products to follow a procedure of traceability. The European Union issued two laws which, amongst others, provided the definitive thrust for setting traceability procedures that met the absolute priority for food safety. One of these, EC Reg. 178/2002 established the general principles and requisites of food legislation and set up the European Authority for Food Safety, establishing procedures in the ambit of food safety. The other, EC Regulation 1830/2003, concerned traceability and the labelling of GM products or their derivatives.

While the objectives and guidelines for the mandatory introduction of traceability in the agri-food system are clear, the effects that this system might have on production, the distribution chain and end-consumers are somewhat controversial. A recent report of the USDA (United States Department of Agriculture) concerning traceability in the USA summarises the results from the most recent economic studies on traceability. For further details on this study see the Internet site http://www.usda.org where the document is available. The essential points that are considered appropriate to stress are as follows: 1) economic efficiency of traceability varies from case to case; 2) in almost all cases complete traceability cannot be achieved or, if it can, it is done so at very high costs; 3) benefits, especially at the production level, are not always assured, and when they are, their distribution is often asymmetric and inefficient.

3 Research outline and motivation

The demand for food safety is an age-old demand from the consumer. Obviously, albeit necessary and a reason for pleasure, food consumption entails the intake into the human organism of completely extraneous substances. Hence a latent demand for food with a zero hazard level has always existed. What has changed in a highly evolved technological society is the relationship of the consumer with the eternal dilemma: need for nutrition vs. risk of introducing harmful substances into the organism.

The society of risk, according to *Beck's* definition, generates as a '*spillover*' permanent new fears and new risks together with the undoubted benefits arising from a hitherto unknown process of technological innovation. Faced with this situation, consumers on the one hand appreciate or negatively experience innovations; on the other, in particular in the food sector, they show increasing demand for safety. Together with a subjective perception of the distribution of probability of the adverse situation, which is completely different from that defined by the experts, this increased demand for food safety systematically generates crises of collective panic (risk of pesticides, BSE, avian flu, GMOs, etc.) which in turn give rise to serious instabilities on agri-food markets.

As has been amply shown by Bevilacqua (2004), the path followed by public and private research in the agri-food sector in the last two decades explains the deep-seated mistrust harboured by many consumers, especially in Europe, over statements coming from the scientific community. Hence any reassurance made by experts in a period of crisis has a negligible effect on consumers.

In the context of industrialised countries, the benefits to be achieved by food safety policies are twofold. They not only allow the saving of human lives and avoidance of suffering, but also reduce the instability of the product markets concerned. As regards the latter, the cases of BSE and avian flu are particularly illustrative. Due to avian flu, poultry consumption in Italy collapsed in the months following the event. Twelve months from the outbreak of panic, consumption was about 18% lower than the previous year's levels. At the same time, prices had fallen by about 8%. The drop in demand and prices following the outbreak hit all the developed countries, but to a different extent. Italy was the country with the largest decline, showing extreme sensitivity to the crisis in the food safety system (Mazzocchi, 2005).

The aim of policies such as those for traceability, set up immediately after the wave of panic generated by BSE, is to reduce the impact of such crises upon markets. One wonders, however, when tackling a completely new consumer hazard like BSE or avian flu, whether this instrument is really effective.

Yet food safety policies almost always entail particularly high social costs. It is therefore important to know the effects on consumption of price increases arising from added costs due to traceability procedures. The conviction is that pursuing the worries of the consumer could have a profoundly detrimental effect upon system efficiency.

The present paper refers to a traceability procedure being studied within the framework of a project at the Agricultural Faculty of Naples University funded by the Italian Ministry of

Agricultural and Forestry Policy. The project sets out to ascertain whether a traceability system can be found for the potato using the analytical method based on Nuclear Magnetic Resonance (NMR), which allows the product to be linked to soil through chemical analysis. In this way, the product's geographical origin can be determined by region, macroregion and/or continent.
Achievement of geographical recognisability would lead to two major results in the ambit of food safety and quality:

1. identification of product origin would combat contraffazioni and fraud, regrettably somewhat widespread, thereby safeguarding production value;
2. characterisation of various products would enhance knowledge of quality aspects and capitalise on their typicality with clear benefits for the consumer.

The research typically adopts a chain approach. However, an important link is the behaviour of consumers faced with end product price variations. In particular, it becomes indispensable to know the effects on demand for the good in question and the reallocation determinants of household expenditure for fresh vegetables.
As regards products, the key focus of our research is the new potato. Though present on the market for no more than two months a year, the new potato is a particular important crop chiefly in Sicily, Campania and Puglia. The fortunes of this crop lie in the fact it ripens before the common potato, reaching markets in a period when there is not yet active competition with the common potato. The economics of the sector comprising the new potato is particularly important. However, the problem which the sector has to tackle is twofold: both competition, especially pricewise, from non-EU Mediterranean countries and, above all, the fact that, after entry into Italy, imported new potatoes can no longer be distinguished from their Italian counterparts. This chiefly occurs due to insufficiently stringent legislation on the origin of farm produce. Hence the objective to set up a traceability system based on an analysis technique such as to detect the source of produce through soil residues on tubers.

4 Data description

In our paper household consumption micro-data are used to distinguish among different household types (e.g. by socio-demographic characteristics, Huang and Lin, 2000) and evaluate how they respond to changes in prices. Households are sampled in a statistically representative way by GFK-Eurisko (a leading market research organization operating in Europe) which collects household real consumption of many products. Households involved in the GfK panel regularly record their purchases through a scanner (ConsumerScan). In accordance with our study purposes, the collected data thus consist of household expenditure and are representative of Italian domestic consumption of fresh vegetables. For each household GFK-Eurisko also collects other information, such as socio-demographic data, that are crucial in a consumer side study.
We collected value (€) and volume (kg.) of purchases made by 2,849 representative Italian households for fresh vegetables (for a total of 49 items), during the period September 2008 - September 2009. Information on prices paid by each household are provided through unit values (€/kg.).
Following the guidelines in Deaton and Zaidi (2002), when the prices were unavailable due to the household's non-consumption of the listed item, we replace unobserved values with the median reported by households per degree of urbanization and region of residence. Quantities (kg.), prices (€/kg.) and expenditure (€) of fresh vegetables are then grouped in 12 homogeneous categories. The final fresh-vegetable groups are: salad, pulses, potatoes,

eggplants and peppers, asparagus, spinach, tomatoes, new potatoes, carrots, fennel, IV vegetables and other vegetables.
As can be seen from the summarised statistics of the vegetable groups included in the model (Tab. 1), for our representative sample the average household expenditure on fresh vegetables per year is nearly €257. Percentages of zero food-consumption (censoring) are substantial, especially for our target food category, new potatoes, which were consumed by only 51.8 percent of households. Italian households spent 1.5 percent of their fresh vegetables budget on new potatoes, 9.1 percent on potatoes, although the prices of the two food items (potatoes and new potatoes) are quite similar (respectively €0.90/kg and €0.96/kg).

Table 1. Percentage of positive consumption, expenditure share and purchase frequency by food group

Fresh Veg. Group	Household purchasing(%)	Mean Veg. Expenditure(%)	Avg. Purch. Frequency (days)
Salads	98.3	12.5	24
Spinaches	62.8	1.9	163
Pulses	79.9	3.6	114
Potatoes	92.7	9.1	56
New potatoes	51.8	1.4	272
Asparaguses	74.0	4.1	131
Tomatoes	97.5	16.0	27
Eggplants and Peppers	98.4	14.4	25
Carrots	91.9	3.5	61
Fennels	80.0	3.4	108
IV Veg.	85.2	12.7	33
Other Vegetables	98.8	17.5	17

Finally, Table 2 describes the variables used in the empirical model. Almost 70 percent of households have no children younger than 15 years old, and 27 percent live in a city with more than 100,000 inhabitants. As regards the educational level of household heads, 44 percent of household heads have high school diplomas or university degrees.

Table 2. Description of variables used in food demand system

Parameters	Variable	Mean	sd
$\gamma_{i,j}$	Price of Salads	2.15	0.72
$\gamma_{i,j}$	Price of Spinaches	1.54	0.62
$\gamma_{i,j}$	Price of Pulses	2.41	0.49
$\gamma_{i,j}$	Price of Potatoes	0.90	0.20
$\gamma_{i,j}$	Price of New potatoes	0.96	0.18
$\gamma_{i,j}$	Price of Asparaguses	4.34	0.98
$\gamma_{i,j}$	Price of Tomatoes	2.05	0.48
$\gamma_{i,j}$	Price of Eggplants and Peppers	1.73	0.35
$\gamma_{i,j}$	Price of Carrots	1.16	0.18
$\gamma_{i,j}$	Price of Fennels	1.43	0.26
$\gamma_{i,j}$	Price of IV Veg.	9.26	2.36
$\gamma_{i,j}$	Price of Other Vegetables	1.82	0.52
β_i	Total fresh vegetables expenditure of the household (€/year)	256.95	219.43
$\delta_{1,i}$	1 if the head of the household has finished High School or Univ.	0.44	0.50
$\delta_{2,i}$	1 if the household lives in North Est Region	0.19	0.39
$\delta_{3,i}$	1 if the household lives in Centre&Sardinio Region	0.21	0.41
$\delta_{4,i}$	1 if the household lives in South&Sicily Region	0.30	0.46
$\delta_{5,i}$	1 for highest income group and 0 otherwise	0.29	0.45
$\delta_{6,i}$	1 if the household lives in more than 100.000 in-habitants city	0.27	0.44
$\delta_{7,i}$	1 if the head of the household is $\geq$ 44 years old	0.64	0.48
$\delta_{8,i}$	1 if the household has more than 2 members	0.53	0.50
$\delta_{9,i}$	1 for the presence of a children $\leq$ 15 years old	0.30	0.46
$\delta_{10,i}$	1 if the household head is employed	.26	.44

5 Traceability: Demand System approach

5.1 Demand Model Specification

In this section we present the economic model adopted to estimate the system of demand. Huge attention in the economic literature has focused on consumer demand modeling. A recent work of Barnett and Serletis (2008) surveys the extensive scientific discussion on the subject. Following other food demand studies applied to cross sectional survey data on expenditure (Huang and Biig-Hwan Lin, 2000; Akbay, *et al*., 2007; Haq *et al*., 2008;) the functional form chosen to specify the model is a linear approximation (LA) of the Almost Ideal Demand system (Deaton and Muellbauer, 1980). Although many alternatives to the AID system exist, including the QAIDS (Banks, *et al*, 1997) which has the advantage of a more flexible specification of the Engel curves, the LA-AIDS model was preferred for its well-known theoretical properties. Furthermore, it presents a computationally reasonable level of complication when a two-stage estimating equations approach for the censored dependent variable is empirically embedded. The adopted procedure (Shonkweiler and Yen, 1999) consistently solves the problem of corner solutions of zero-food consumption.

We consider a consumer multi-stage budgeting process that implies home consumption of fresh vegetables as strictly separable from the demands for other goods. This hypothesis justifies the exclusion of other goods expenditure on which information is not fully available. The assumption is reasonable if the estimation objectives are restricted to understanding consumption substitutability in the same food category.

Deaton and Muellbauer (1980) consider a first order approximation of the demand functions allowing exact aggregation over consumers, and propose a system of equations for the budget share w_i of the *i*th good (LA model) as

$$w_i = \alpha_{i*} + \sum_{j=1}^{I} \gamma_{ij} \ln P_j + \beta_i \ln\left(\frac{X}{P_*}\right) + u_i \qquad \forall i = 1, \ldots, I \tag{1}$$

where P_j is the price of the *j*-th good, X is the total expenditure on food categories in the system, α_i, β_i and γ_{ij} are parameters for the demand shifter, for own-, cross-price and expenditure elasticities respectively, u_i is the error term and P_* is a price index, useful to standardize all prices. It must be recognized that the possible measurement error introduced by the Stone price index would make the estimate inconsistent. Hence, in line with other studies we use the following specification (Moschini, 1995):

$$\ln P_* = \sum_{i=1}^{I} \bar{w}_i \ln P_i. \tag{2}$$

where $\bar{w}_i$ is the mean budget share. We also introduce a set of K demographic attributes that are demand shifters, such that:

$$\alpha_{i*} = \alpha_i + \sum_{k=1}^{K} \delta_{ik} D_k \qquad \forall K. \tag{3}$$

The economic theory provides a set of restrictions that are known as homogeneity, adding-up and symmetry. The homogeneity and symmetry conditions are respectively imposed by:

$$\gamma_{ij} = \gamma_{ij} \qquad \forall i, j = 1, \ldots, I; \tag{4}$$

and

$$\sum_{i=1}^{I} a_i = 1 \qquad \forall i = 1, \ldots, I \tag{5}$$

As the adding-up issue is still an open question in censored demand systems, following other studies we prefer to perform estimation ignoring the restriction (Drichoutis *et al.*, 2008).

5.2 Econometric issue

The statistical and economic importance of censoring data has amply demonstrated, starting from the works by Gronau (1974) and Heckman (1979). In consumer demand studies the zero-food consumption problem arises because only a subset of households shows a positive consumption for the *i*-th good. If a consumption equation were to be based only on the subset, it would probably estimate a significant effect on the *level* of consumption for those covariates that, instead, affect the probability of positive consumption (a spurious relation). More formally, estimates would be inconsistent but simple procedures fix the problem, treating it as a specification error. Heckman (1979) suggests a simple two-step approach to solve the censoring problem: in the first step the probability of non-nill in the censored variable is estimated, then in the second step the new set of covariates includes the inverse Mills ratio to correct for the selection bias.

In a demand system case, since the seminal work of Heien and Wessels (1990), several empirical procedures for censored data have been developed such as those suggested by Perali and Chavas (2000) and Shonkweiler and Yen (1999). Following Shonkweiler and Yen (1999) the zero-food consumption for a demand system of *I* equations is modelled as below:

$$y_1^* = (x_1 \beta_1)\Phi(x_2 \hat{\beta}_2) + \delta\phi(x_2 \hat{\beta}_2) + e_1 \qquad \forall \begin{cases} i &= 1, \ldots, I \\ n &= 1, \ldots, N \end{cases}$$

and

$$e_i = u_i + (x_{1,i}\beta_{1,i})[\Phi(x_{2,i}\beta_{2,i} - \Phi(x_{2,i}\hat{\beta}_{2,i})] + \delta_i[\phi(x_{2,i}\beta_{2,i}) - \phi(x_{2,i}\hat{\beta}_{2,i}).$$

where $\phi(x_2\hat{\beta}_2)$ and $\Phi(x_2\hat{\beta}_2)$ are the probability density function (PDF) and the cumulative distribution function (CDF) respectively, which are obtained from a probit model using the equation (6) in the first stage,

$$y_2^* = (x_2\beta_2 + e_2) \qquad (6)$$

with

$$y_2 = \begin{cases} 1 & if \quad y_2^* > 0 \\ 0 & if \quad y_2^* = 0 \end{cases}$$

and

$$y_1 = y_2 y_1^*$$

To estimate a system of *I* equations, an ITSUR approach jointly considers the covariance in the consumption equations. For the same reason as in the single-equation case due to the downward bias of the population variance, we also bootstrapped the standard errors.

6 Empirical results

The entire sample was used in the above-specified model, addressing the problem of corner solutions of non-positive food consumption. Overall, the demand system results (Tab. 3) show a reasonable goodness-of-fit in spite of the cross-sectional characteristics of our estimation: R^2 values lie between 0.22 (new potatoes) and 0.78 (other vegetables). Coefficients on the PDF (δ_ϕ) are on the whole statistically significant (except for the spinach equation) and positive (except for fennel equation). It strongly supports the idea that correction for sample selection bias was necessary. Although 65 percent of the estimated parameters are different from zero at the 10 per cent level or less, almost all the own-price parameters are significantly different from zero (except for the potato equation).
As discussed in the previous section the cross-price parameters are symmetric due to the imposed restriction $\gamma_{ij} = \gamma_{ji}$. Socio-characteristic variables included in the model also influence demand statistically, especially the regional dummies. Most degrees of urbanization and employment status of the household head dummies are also statistically significant.

Table 3. Estimated parameter demand

	Salads	Pulses	Potatoes	Eggpl.&Pepp.	Asparag.	Tomatoes	New potatoes	Carrots	Fennels	Oth. Veg.	Spinach	IV Veg.
γ_{salads}	0.041***	0.007**	0.009**	-0.014***	-0.009**	-0.032***	-0.009***	-0.012***	-0.001	-0.018***	-0.007***	0.034***
γ_{pulses}	0.007**	0.014***	-0.005	0.007*	0.003	0.010**	0.005*	-0.004	0.007**	-0.015***	0.001	-0.009***
$\gamma_{potatoes}$	0.009**	-0.005	0	-0.021***	0.007*	0.010*	0.015***	0.010***	-0.006*	0.001	-0.001	-0.014***
$\gamma_{egg.\&pep}$	-0.014***	0.007*	-0.021***	0.061***	0.001	-0.015***	-0.003	0.007*	0.002	-0.009*	-0.007*	-0.009**
$\gamma_{asparag.}$	-0.009**	0.003	0.007*	0.001	0.010*	0.016***	-0.004	-0.003	-0.003	-0.008*	-0.005*	-0.002
$\gamma_{tomatoes}$	-0.032***	0.010**	0.010*	-0.015***	0.016***	0.024***	-0.006	0.011***	0.002	-0.022***	0.001	0.007
$\gamma_{newpota.}$	-0.009***	0.005*	0.015***	-0.003	-0.004	-0.006	0.012***	0	0.005*	-0.015***	-0.001	-0.001
$\gamma_{carrots}$	-0.012***	-0.004	0.010***	0.007*	-0.003	0.011***	0	0.020***	0.004	-0.005*	-0.003	-0.010***
$\gamma_{fennels}$	-0.001	0.007**	-0.006*	0.002	-0.003	0.002	0.005*	0.004	0.021***	-0.014***	0.002	-0.009***
$\gamma_{Oth.Veg.}$	-0.018***	-0.015***	0.001	-0.009*	-0.008*	-0.022***	-0.015***	-0.005*	-0.014***	0.088***	-0.006**	0.011***
$\gamma_{Spinach}$	-0.007***	0.001	-0.001	-0.007*	-0.005*	0.001	-0.001	-0.003	0.002	-0.006**	0.013***	-0.004
$\gamma_{IVVeg.}$	0.034***	-0.009***	-0.014***	-0.009**	-0.002	0.007	-0.001	-0.010***	-0.009***	0.011***	-0.004	0.016***
β_i	0.004**	-0.010***	-0.002	0.008***	0.012***	0.001	-0.003	-0.002*	-0.023***	0.013***	-0.008***	-0.001
δ_1	-0.007**	0.001	-0.007***	-0.004	0	0.004	0.001	0	0	-0.011***	0.004**	0.019***
δ_2	0.027***	0.005**	-0.021***	-0.004	-0.009***	-0.013***	-0.003	0.002	0.005**	0.032***	0.005*	-0.024***
δ_3	0.010**	0.003	-0.009**	-0.001	0.002	0.024***	0.016***	-0.008***	-0.006***	-0.003	0.009***	-0.021***
δ_4	0.001	0.022***	0.031***	0.049***	-0.017***	0.015***	0.016***	-0.002	-0.002	0.005	0.011***	-0.106***
δ_5	0.014***	-0.006***	-0.003	0.001	-0.010***	0	-0.003	-0.003**	-0.005***	0.007*	-0.004***	0.010***
δ_6	0.003	0.006***	-0.011***	0.008***	0.009***	-0.008**	0	-0.003**	-0.002	-0.006*	0.005***	-0.003
δ_7	0.003	0.003	0.001	-0.020***	0.018***	-0.010**	0.003	-0.005***	0.002	0.003	-0.002	0.001
δ_8	-0.002	-0.005***	0.004	0.012***	-0.013***	0	0.005***	0.001	0.002	-0.008**	0.002	0.011***
δ_9	0.012***	-0.003	0.001	0	-0.005	0.003	-0.004*	0.002	0.003	-0.009**	0.001	-0.007
δ_{10}	-0.008*	0.006***	0.008**	-0.027***	0.008**	-0.010**	0.004*	-0.006***	0.002	0	0.001	0.018***
δ_ϕ	0.481***	-0.019*	0.135***	0.518***	0.054***	0.144***	0.047***	0.034***	-0.055***	0.272***	-0.006	0.042***
α_i	0.035***	0.084***	0.110***	0.100***	-0.03	0.133***	0.019	0.081***	0.180***	0.105***	0.081***	0.102***
R^2	0.65	0.41	0.60	0.71	0.34	0.71	0.22	0.47	0.43	0.78	0.26	0.58

legend: * $p< 0.10$; ** $p< 0.05$; *** $p< 0.01$

Marshallian own- and cross-price average elasticities and expenditure average elasticities are shown in Table 4.

Table 4. Uncompensated price, cross-price and expenditure elasticities by fresh vegetables group (mean value)

	Salads	Pulses	Potatoes	Egg.&Pep.	Asparaguses	Spinaches	Tomatoes	New Potat.	Oth. Veg.	Carrots	Fennels	IVVeg.
Salads	**-0.68**	0.05	0.07	-0.11	-0.07	-0.05	-0.26	-0.07	-0.15	-0.10	-0.01	0.26
Pulses	0.17	**-0.68**	-0.09	0.19	0.09	0.02	0.26	0.12	-0.29	-0.08	0.17	-0.18
Potatoes	0.09	-0.05	**-1.00**	-0.22	0.08	-0.01	0.10	0.16	0.02	0.10	-0.07	-0.14
Egg.&Pep.	-0.10	0.05	-0.15	**-0.60**	0.01	-0.05	-0.11	-0.02	-0.07	0.05	0.01	-0.07
Asparag.	-0.19	0.05	0.11	-0.01	**-0.83**	-0.09	0.25	-0.07	-0.18	-0.06	-0.05	-0.07
Spinaches	-0.21	0.03	0.00	-0.19	-0.16	**-0.56**	0.08	-0.02	-0.17	-0.09	0.07	-0.09
Tomatoes	-0.20	0.06	0.06	-0.09	0.10	0.01	**-0.85**	-0.04	-0.14	0.06	0.01	0.04
New Potat.	-0.32	0.20	0.57	-0.09	-0.13	-0.02	-0.21	**-0.57**	-0.53	-0.01	0.21	-0.03
Oth. Veg.	-0.11	-0.09	0.00	-0.06	-0.05	-0.04	-0.14	-0.08	**-0.52**	-0.03	-0.08	0.05
Carrots	-0.31	-0.10	0.26	0.19	-0.08	-0.07	0.29	-0.01	-0.11	**-0.48**	0.12	-0.26
Fennels	0.05	0.19	-0.10	0.12	-0.04	0.05	0.12	0.13	-0.24	0.12	**-0.50**	-0.15
IVVeg.	0.24	-0.06	-0.10	-0.06	-0.01	-0.02	0.05	-0.01	0.08	-0.07	-0.06	**-0.88**
Expenditure	1.03	0.77	0.98	1.06	1.22	0.74	1.01	0.89	1.08	0.94	0.47	0.99

Values calculated through Yen *et al.*, procedure (2002).

The elasticities are calculated by the parameters estimated (Tab. 3) through the procedure suggested by Yen *et al.*, 2002:

$$\eta_{ii} = (\gamma_{ii} - \beta_i \widehat{w}_i)\Phi(x_2\beta_2)/\widehat{w}_i - 1, \quad (7)$$

$$\eta_{ij} = (\gamma_{ij} - \beta_i \widehat{w}_j)\Phi(x_2\beta_2)/\widehat{w}_i, \quad (8)$$

and

$$exp_i = 1 + \Phi(x_2\beta_2)\beta_i/\widehat{w_i}. \quad (9)$$

The sign of own-price and expenditure elasticities are consistent with theory, and their magnitudes are within the expected range.

The demands for IV vegetables are more price-sensitive to price changes (η_{ii} = -0.88) than cheaper food such as carrots (η_{ii} = -0.48), new potatoes (η_{ii} = -0.57) and fennel (η_{ii} = -0.50). Compensated cross-price elasticities are generally small in magnitude, especially when there is a complementarity relation ($\eta_{ij} < 0$). The relationship of complementarity ($\eta_{ij} < 0$) and substitutability ($\eta_{ij} > 0$) between fresh-vegetable categories indicate changes in consumption pattern resulting from price changes.

Combining the box plot and density trace (or smoothed histogram) into one diagram (Hintze and Ray, 1998) the distribution of heterogeneity among households may be further explored for new potato own-price elasticities. Figure 1 shows two distinct peaks around the values of η_{ii} equal to - 0.6 and - 0.4. The heterogeneity is due mainly to regional characteristics of the population, as demonstrated by Fig. 2. In southern Italy demand for new potatoes is more inelastic than in northern or central Italy.

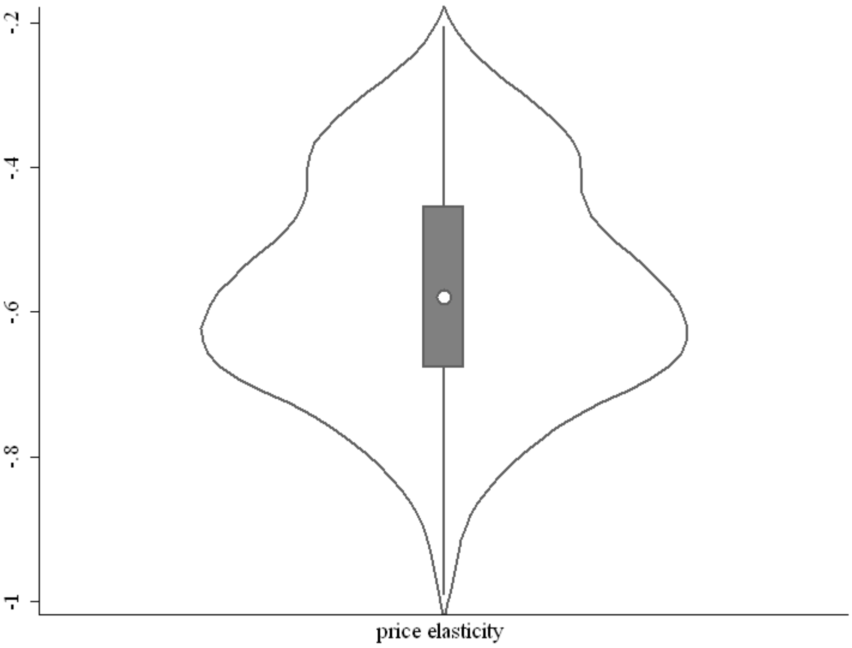

Figure1. Violinplot of new potato own-price elasticity

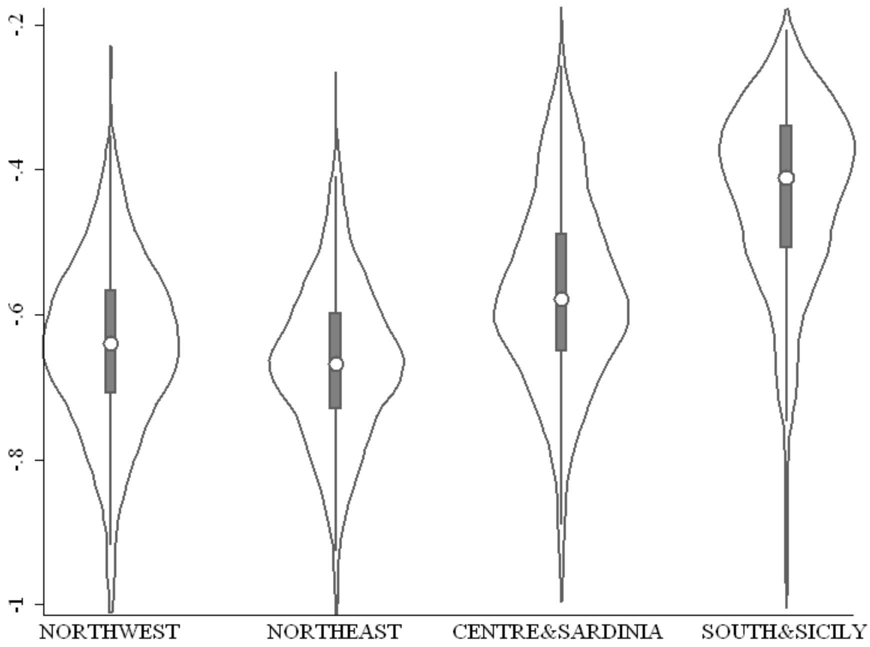

Figure 2. Violinplot of new potato own price elasticity by region

The consequences of a *j*-th good price change on the demand for i goods (*ceteris paribus*) is reported by each *j*-th column (Tab. 4). As regards the *new potatoes* column, the results strongly confirm a relation of substitutability with potatoes (η_{ij} = 0.16), fennel (η_{ij} = 0.13) and pulses (η_{ij} = 0.12). Although some complementarities exist, they are small in magnitude and except for salad (η_{ij} = -0.07) and other vegetables (η_{ij} = -0.08) they are not statistically significant.

The consequences of changes in demand for the *i*-th good due to the change in *j* good prices (*ceteris paribus*) can be investigated from each *i*-th row. An increase in the price of *potatoes* (η_{ij} = 0.57) has practically the same impact on the demand for *new potatoes* as an increase in the price of *new potatoes* (η_{ii} = 0.57). Unexpectedly, both other vegetable (η_{ij} = -0.53) and salad prices (η_{ij} = -0.32) also seem to considerably affect the demand for new potatoes. A reasonable explanation lies in the fact that both demands are quite inelastic, and are characterized by a high expenditure share. An increase in their prices causes a reallocation of the expenditure among the goods, with direct repercussion on *new potato* consumption.

7 Concluding remarks

The purpose of our research was to estimate the effects of potential price increases upon fresh vegetable demand resulting from the introduction of an innovative method of traceability that ensures the geographical identification of the product. Although our study focused on the new potato, by implementing a demand estimation model for the whole category of fresh vegetables we were able to obtain detailed information on almost all the other complementary and substitute products of the new potato. The study was carried out in 2009 using consumption data for about 3,000 Italian households that were statistically representative of the nationwide population.

The hypothesis empirically tested in this study was motivated by the fact that, with respect to food safety, consumer attitudes and those of policy makers appear more focused on reassurance at any cost rather than actual knowledge of the effects on markets arising from the introduction of regulatory standards that impose product traceability along the whole chain. this behaviour has not always obtained the desired results. Faced with the mere perception of hazard for a certain product, consumers react in the vast majority of cases with behaviour of real collective panic towards that project or category of products, despite the presence of control and traceability systems.

From the results of our study it may be inferred that an increase in the new potato price affects the quantity demanded. The extent of the effect was measured in terms of own-price elasticity (-0.57). The substituted products were common potatoes (0.16), fennel (0.13) and pulses (0.12). The estimates, as was to be expected, show the product's price sensitivity.
Beyond the value of elasticities calculated, it is necessary to stress that the common potato is, in terms of food habits, a direct substitute of the new potato. In the presence of similar prices between the two potato types, increasing the price scissor would amplify the substitution effect.

The cost of implementing the new traceability system is not yet known. However, some reflections may be made on the new potato market according to how the system is introduced. Let us assume that a traceability system will become mandatory for all the products of the same goods category. This will lead to the current situation in which, assuming that the unit costs of implementation are the same for each product, a negative externality is induced in the market whose costs are likely to be borne by the end consumers. This has already happened for other product categories in which the obligation of traceability entailed an inefficient allocation of costs among the economic agents of the chain. This holds even more for production in which an almost entirely competitive form of market may be observed.[1]
Alternatively, one could conceive of a voluntarily implemented traceability system, like that currently researched by the University of Naples, which also certifies product origin. In this case, entrepreneurial success would stem only from consumer willingness to pay a premium if the certified end product is perceived as a superior good. There is extensive empirical evidence in the literature in which this behaviour has been observed but, in the case of the Italian new potato, has not yet been proved.[2]
This latter aspect is particularly important in light of the joint analysis of cross elasticities between the new potato and the common potato. Indeed, in the event of a price increase in new potatoes, the latter is substituted by the common potato at a rate of 0.16. Otherwise, that is if it is the price of the common potato which rises, new potato consumption grows by 0.57. It may thus be stated that consumers perceive the common potato as a slightly inferior good to the new potato. The implication is that the latter is already considered a superior good. However, an increase in the price scissors in favour of the common potato would have a significant effect on new potato consumption.

1. Many farm products in Italy show that in the business phase the production costs do not deviate significantly from the sale price of the product.
2. Though, this study phase has already been launched within the TIPIPAPA-MIPAF project, the results will be available at the end of 2010.

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