Consumer attitudes toward GM food with hypothetical functional characteristics

Floriana Marin, Sandra Notaro

University of Trento, Italy

flomarin@itc.it

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Summary

Since their introduction in the early 1990s, genetically modified organisms in agriculture tended to emphasize improved yield. Europeans, perceiving unacceptable risk and too little benefit, resoundingly disapproved of GMO use in agro-food processes. More recently, research has turned to developing products that use GMO components that better match consumer interest, including nutritionally enhanced foods, environmentally friendly crops, and other areas. The question that arises is whether Europeans perceive that the new, prospective benefits outweigh the olds risks, opening the market to such products.
This paper investigates consumer preferences for a number of hypothetical genetic modifications in a widely consumed food product: yoghurt. We explore the issue using discrete-choice, multi-attribute, stated-preference data. Our analysis of the data shows that consumers attribute low importance to prospected benefits in judging gene technology applications. Moreover, data demonstrates that consumers don't feel that labels and certification alone offer sufficient safeguards from perceived danger. Conversely, better information through scientific research does seem to have an impact.

KEYWORDS: GMOs, functional properties, willingness to pay, choice modelling

1. Introduction

In 2006, the sixth edition of Eurobarometer survey on risk perceptions was released (Eurobarometer, 2006). Compared to the previous editions, this analysis revealed that Europeans are more confident about the positive contribution that technology transfer can bring to society. People were more informed, and a optimism about biotechnology approached levels registered in early 1990s, when the first Eurobarometer survey was carried out. That is a reversal of the trend of decline registered in the period 1996-2005.
Nevertheless, the great majority of respondents appeared seriously convinced that their health could be damaged by biotechnology applications in the agro-food sector, and particularly by genetically modified organisms (GMOs). Eurobarometer results pointed out the persistence of strong concerns with food safety and quality. GMOs are seen as not useful, risky and morally unacceptable (ibid.).
People clearly identified several factors as dangerous. First was the risk that antibiotic resistance might be transferred to humans through consumption of GM food. Moreover, many people are afraid that environmental equilibrium may be damaged by crosspollination between GM and non-GM crops.
In this study, we tried to assess whether consumers have lower aversion to GM agro-food products if these products incorporate potential benefits to the consumer. In particular, we try to verify if consumer attitudes towards GMOs differ for various types of benefits. Because yoghurt is an important locally produced good, we used it on our study.
The remainder of the paper is organized as follows. Section 2 illustrates the background and motivation to this study, section 3 describes objectives, section 4 data and methods, estimation and results are illustrated in section 5, and we draw our final remarks in section 6.

2. Background

Several studies have demonstrated that uncertainty about agro-biotechnology applications applies to many fields, including human health, sustainability, environment safety, and ethical issues (Martinelli, 2004; Bucchi & Neresini, 2004; Frewer, 2003, Wolt & Peterson, 2000). Altogether, these factors are decisive in building attitudes towards GM products (Martinelli et al., 2005; Slovic, 2000). Moreover, Science itself is intrinsically unable to provide univocal and thorough knowledge on agro-biotechnology implications for present and future generations. Scholderer & Frewer (2003) and Bucchi & Neresini (2002) have proved that scientists' conflicting statements about GMOs effects emphasize the public concern. Consequently, Europeans feel very confused as regards different applications of agro-biotechnology (Gaskell et al., 2004; Observa 2000, 2002, 2003; Evans & Durant, 1995). In particular, citizens-consumers tend to base their evaluations on self-made estimates of the risks and the benefits of a given technology and these appraisals can strongly differ from those of experts and technicians (Savadori et al., 2004). As a consequence, GM applications in health care receive great support, while GM food and xenotransplants seem to be least supported (Eurobarometer, 2003; Frewer & Shepherd, 1995; Bredahl et al., 1998). Generally, opposition seems to be stronger when people recognize only the perceived risks of a technology application, while the benefits are of negligible importance (Gaskell et al., 2004). Thus, consumers can have distinct opinions of the same technology according to its purpose: if DNA technologies are beneficial for health, they are likely to receive greater support than technologies that do not offer similar benefits (Gaskell et al., 2003).

On the other hand, GMO cultivation is rapidly spreading around the world. The International Service for the Acquisition of Agri-Biotech Applications (ISAAA) reports that in their first decade of commercialization (1996-2005), the global area of GM crops has increased more than fifty fold. In 2005, biotech crops covered about 90 million hectares, an increase of 9 million hectares compared to the data available for the year 2000 (ISAAA, 2005). This trend in GMO crop diffusion might suggest that farmers may have some advantage in cultivating GM plants. In fact, the first generation of GMOs was developed to increase yields, tackling production problems such as the cost of fertilizers, adverse weather and climatic conditions, and plant pests and weeds.

3. Objectives

The introduction of crops produced with biotechnologies has raised concerns, shedding light on the need to develop more careful research with regards to other aims than simply benefits to farmers (Phillips & Corkindale, 2002). At present, the great challenge for the DNA transfer technologies in agriculture is to develop new varieties with unique functional properties that benefit consumers. Another crucial priority is environmental sustainability. In this view, GM plants can be bred to supply desirable nutrients for human diet, to improve taste in foods, to support environment-friendly production practices, but also to produce medicines and vaccines (ABEurope, 2003). As a consequence, it is possible that future GM food products with ascertained benefits for their users will be available on the shelves (Marin & Martinelli, 2005). This possible scenario raises the question as to whether consumers will change their attitudes toward GM products given promised potential benefits and partially known risks. Thus, we want to investigate whether development of GM products more attentive to consumer needs could outweigh the negative perceptions of agricultural biotechnologies. Accordingly, our study interest lies in the citizen-consumer attitudes towards GMOs and specifically in the factors that can affect final choice when different purposes are associated with GMOs in food processing.

Deep understanding of citizen reaction to technology transfer and the ability to properly interpret the motivations behind such responses are crucial to institutions for governing innovation democratically and efficiently. Analyzing how positive or negative attitudes

translate into actual behavior can make a valuable contribution toward identifying people's needs and priorities with reference to gene technology.
In this framework, using an economic approach, we try to understand purchase behavior as a tangible expression of an individual's choice to consume or reject GM food products.

4. Data and methodology

The evaluation of consumers' attitudes towards OGM was undertaken for the Province of Trento, which is located in north eastern Italy. In this territory the economy is mainly based on agricultural activities, environmental services, and tourism. As dairy production is one of the most representative activities in Trentino, we selected yoghurt as a target product for our analysis. In our simulation, yoghurt is hypothesized to be the product of conventional food processes or, alternatively, of practices based on GMOs for different aims, namely higher agricultural yields, lower environmental impacts, or the hypothetical prevention of serious health diseases.
The telephone survey was carried out during the Spring of 2006. We asked to a random sample[1] of 532 Trentino people[2] to choose the preferred yoghurt among 4 alternatives in a choice experiments context.
We apply a Discrete Choice (DC) approach (Train, 2003; McFadden, 1974a, 1974b, 1976, 1981, 2000; McFadden & Ruud, 1994; McFadden & Train, 2000; Hensher *et al.,* 2005) to model consumer preferences for different hypothetical GMOs in food.
DC models have been applied in marketing, transport economics, and recently in environmental economics and agro-food marketing to estimate the value of goods characterized by the absence of a market price (Adamowicz *et al.*, 1994).
Consumer preferences about GMOs in food were previously analyzed using choice modeling. Lusk *et al.* (2003) examined the use of GM in cattle breeding, Novoselova *et al.* (2005) in the pork production chain, Baker and Burnham (2001, 2002) in corn-flakes. Hu *et al.* (2004) compared individual valuations for different perceived risks and benefits associated with GMOs. Burton and Pearse (2002) estimated willingness to pay for different characteristics of conventional and GM beer, while Canavari *et al.* (2005a, 2005b) focused on WTP for eggs and biscuits containing GM ingredients with different purposes (namely, increasing yields and improving nutritional content).
DC methods draw upon Lancaster's economic theory of value (Lancaster, 1966) and Random Utility Theory (Marschack, 1960, McFadden, 1974a).
Lancaster describes each good as a combination of characteristics or attributes. Every attribute has a specific role in the definition of the total value of the good.
Following the Random Utility Theory, the utility that the decision-maker *n* obtains from alternative *j* (U_{nj}) is known to him but not to the researcher. The researcher can only observe some attributes of the alternatives and of the decision-maker. The difference between U_{nj}, the true utility, and V_{nj}, the observed utility, is ε_{nj}, that captures all the factors not included in V_{nj} (Train, 2003). Assuming a maximizing utility behaviour, alternative *i* will be chosen among all the alternatives if it provides the decision-maker with the highest utility.

$$U_{nj} = V_{nj} + \varepsilon_{nj}$$

$$P_{ni} = \text{prob}(U_{ni} > U_{nj} \quad \forall\, j \neq i)$$

[1] People were selected from the Trentino telephone directory; the use of the MS Excel® Random Number Generator enabled us to draw the names randomly.
[2] The target for our study was specified as the person responsible for household food purchases.

$$= \text{prob}\,(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj} \quad \forall\, j \neq i) \qquad \textbf{Eq.(1)}$$
$$= \text{prob}\,(\varepsilon_{nj} - \varepsilon_{ni} < V_{ni} - V_{nj} \quad \forall\, j \neq i)$$

Different levels of attribute may be found in the good and the total utility of the good can be viewed as the sum of the individual utilities provided by each attribute. Every change in the attribute levels produces different goods or services: DC Methods focus exactly on the value that people confer on such changes in attributes.
In this study, when the consumer buys a yoghurt, the combination of attributes she/he is looking for could be given by the price, health functionalities, the kinds of production processes used, or the percentage of GMOs presence. Considering the different yoghurt options together, a consumer compares the costs and the benefits of each alternative on the basis of her/his personal preferences for the attributes. The final choice will be the yoghurt that maximizes her/his utility, the one for which she/he is most willing to pay.
Data for the DC analysis are collected using specifically designed questionnaires in which respondents are faced with different bundles of attributes and levels. People interviewed are asked to choose the product with the best combination of attributes and levels, that is which provides the highest level of utility. In order to obtain monetary values, different prices for different bundles of attributes are included in the choice sets.
Indeed, a key element in performing a DC analysis is represented by the choice of attributes and levels.
In order to determining relevant yoghurt attributes and for designing alternative choice scenarios we performed two focus groups (Marin & Martinelli, 2006). Attributes identified were the food processing (conventional *vs.* biotechnology), the presence/absence of health and environment-friendly properties, and the price.
Only the price was expressed with quantitative levels[3]. The other attributes were specified as dummy variables (0,1).
Questionnaires consist of four sections. The first part introduces the general objectives of the study. Moreover, some attitudinal questions are included to get the respondents involved in the interview and to collect general information on their ethical values, priorities and habits. Accordingly, questions were asked on the general knowledge of GMOs, on the stated attitudes toward different uses of gene technology (by Likert scales) and on the purchase behavior with reference to yoghurt.
The second set of questions involves the respondents in two choice experiments among different kinds of yoghurt. This section provides the main core of the survey, namely the monetary valuation of the different functionalities associated to gene technologies in food processes. People are presented with a short description of the available options[4]:

- a conventional yoghurt, which was specified to be the respondent's generally purchased one;
- a yoghurt obtained from milk derived from GM feed for increasing yields;
- a yoghurt obtained from GM milk with an hypothetical low environmental impact;
- a yoghurt containing GM enzymes with hypothetical anticancer properties.

The third part of the survey aims at investigating the purchase habits for particular products, like the organic food, the environment-friendly products, the fair-trade goods and the nutritionally enhanced (functional) food. Two specific questions are addressed to investigate the risk-taking attitude and the willingness to support institutional initiative to promote local agro-food production (namely, a local quality brand).

[3] We identified the price levels as percentage increases or decreases from a baseline determined on the average price of a conventional product.
[4] Each choice experiment contains the "None of these", the "Do not want to answer" and the "Do not know" options.

Finally, the survey collects the usual information on the socio-economic and demographics characteristics of respondents.
Models used to estimate the willingness to pay (WTP) for alternative yoghurts are the *Multinomial Logit* (Equation 2) and the *Random Parameter Logit* (Equation 3).
The Multinomial Logit Model is the generalization to more than two alternative of the Logit Model. If the error terms are independent and identically Gumbel distributed, with location parameter 0 and scale parameter μ, the probability that a given individual choose alternative *i* is given by the following Logit probability:

$$P_{ni} = \frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{nj}}} \qquad \textbf{Eq.(2)}$$

where: β' is the inverted vector of estimation parameters and X is the vector of the attributes known by the researcher.
A limitation of the Multinomial Logit model is the property of the Independence from Irrelevant Alternatives (IIA). The Mixed Logit Models partly overcome this limitation.
Among these, the Random Pareter Logit Model allows coefficients to change randomly in the population. In this way it allows to consider taste heterogeneity.
The probability that a given individual chooses alternative *j* is given by:

$$Pnj = \frac{1}{R}\sum_{r=1}^{r=R}\left[\frac{\exp^{(\chi_{nj}\phi_{nr})}}{\Sigma_{k=1}^{k=m}\exp^{(\chi_{nk}\beta_{nr})}}\right] \qquad \textbf{Eq.(3)}$$

where Pnj is conditional on the distribution of β and represents the average value obtained from R repeated draws of β from the distribution f(β).

5. Results

The questionnaire was submitted to a random sample of 532 individuals. The response rate was 60,5%, which is typical for telephone based surveys (Bateman et al., 2002).
The sample consisted of a majority of women[5] (57%) and in most of the cases was represented by quite young people (64% within the 20-40 year class and 28% within the 41-60 class). The majority of the respondents' households were composed by at least 3 units (69%) and in 28% of the cases there is at least one child less than 14 years old from birth. Average income per household was more than 2000 €/month in about 45% of the cases, while the educational level was good because 33.5% have a high school diploma and 40% a university degree.
Erudition on the issues concerning Genetically Modified Organisms appeared to be spread, as 94% of the sample stated that they know what the term GMO means. As regards general attitudes toward gene technology applications in agriculture, only 9.4% of the respondents strongly agree with the growth of GM crops aimed at increasing yields for farmers and, in case, at reducing prices for consumers, while 34.6% totally disagree. On the contrary, 23.8% and 24.1% respectively agree with the development of *environment-friendly* GMOs and GMOs with anti-cancer properties. The quota of discordant opinions for the *environment-friendly* GMOs was 39.4% and it rose to 41% for the health functional GMOs. We noticed that percentage of acceptance/discordance for these last two kinds of GMOs were very close, probably depending on the fact that some people may have interpreted the

[5] Women are more represented in the sample because we asked for the person who generally buys food.

lower concentration of pesticides in crops due to the use of *environment-friendly* GMOs as an additional health benefit rather than as a way to preserve ecosystem.
Moreover, a number of respondents could have created two categories in their mind: benefit for farmers and benefit for consumers. If this is true, in responding to this question they have not weighted separately the two options *environment* and *health*.
Finally, some respondents may have not believed credible the anti-cancer functionality.
The amount of uncertain people (partly agree and partly disagree) was more than a half in each of the applications considered: specifically, 56% of respondents were doubtful about the use of GM crops for increasing yields, 55% were uncertain whether to support or not *environment-friendly* GMOs and nearly 59% had some hesitation in giving definite judgments on functional GMOs.
Uncertainty reflects also on the need for better and more complete knowledge on agro-biotechnologies to be obtained by scientific research (47% strongly agree and 35% fairly agree that public research on this matter should be supported). This data is coherent with the total amount of people who were unwilling to bid 50 Euros with a probability of 1% to win 5000 Euros, that has been taken as a proxy for the risk-aversion quota in the sample (79.5%). This value suggests that in presence of uncertainty about the future respondents prefer refusing great compensations than losing their assured stake.
Almost all the respondents stated to purchase yoghurt produced in Trentino Alto Adige (97%). Hedonistic components (specially taste) and intrinsic health properties (mainly, the action on the immune and digestive systems) were identified as the main purchase reasons for the yoghurt as a snack or light meal (50.4% and 41.1% respectively). Price has little influence on the decisions to consume yoghurt (only 6.6%), but its importance increases when conventional and functional yoghurts are compared together. Accordingly, while taste ranks first, price is the second and third most important factor affecting the choice of a specific brand of yoghurt.
The frequent purchases of ecologically sound (48%), fair-trade (44%) and organic (43%) products suggests the idea of an ethical attitude among respondents. 44% of the people, instead, have never bought nutritionally enhanced food before, showing a lack of interest in this kind of products.
In a region that elected the sustainable development as a guideline for the local economic development, like Trentino is, the relevance of aspects pertaining quality, healthiness and integrity of cultures may appear evident in people's imaginaries. Thus, in the general vision of the Trentino supply, agro-food product seems already to incorporate higher value attributes. Probably depending on this matter, about one third of the sample (34.6%) stated that they would not be willing to pay extra money for a local Non-GM mark with the aim of further promoting the local production, while 23% proved to be hesitant about this opportunity.
Purchase behaviors and willingness to pay for the different options of yoghurt were observed using the Multinomial Logit and the Random Parameter Logit models[6].
The dependent variable for both the models was specified to be the choice (0,1) among the available yoghurt alternatives on the basis of the price (in Euro), the process (conventional or GM) and the benefit (yield increase, environment-friendly, health functionality) attributes.
Parameter estimates provided by the Multinomial Logit Model are reported in Table.1. The price coefficient has a negative sign, as expected, indicating that an increase in the price of yoghurt will produce a reduction in the utility for the consumer.
The variables associated to gene transfer techniques have also negative sign, suggesting that the utility for respondents is inversely related to the presence of GM attributes. The GM

[6] 634 observations were usable for the Discrete Choice Analysis.

variables in the model are statistically significant at the 0.05 level, while the price was significant only at 0.1 level.
The values provided in Table 1 show that, among the negative attitudes toward GM yoghurt consumption, the functional yoghurt appears to be the less disregarded, with a coefficient of -1, while the alternative containing milk from GM feed for increasing yields is the more disliked. This result suggests that our respondents have different valuation criteria for judging the GM applications, and that the presumed benefit could have an influence in determining behaviors toward GMOs.
Monetary values are defined identifying the partworths associated with some changes in the attribute levels. Namely, the partworths describe the rate at which our respondents are willing to trade-off conventional yoghurt with each of the GM yoghurts[7].
Accordingly, the GM yoghurt related to increasing yields would need a 2.8 Euros discount for leaving our respondents indifferent as compared to the conventional alternative. Similarly, environment-friendly GM yoghurt would require a price discount of 2.5 Euros, while this value becomes lower for the functional GM option (1 Euro discount) (See table 2). The negative willingness to pay for GM yoghurts suggests that currently there is a flat denial of these products among our respondents. They firmly believe that conventional yoghurts are strongly preferable to the GM ones, even if enriched with new appealing properties.
The low difference in price discounts between the yoghurt related to increasing yields and the environment-friendly one reflects a discordance with attitude expressed before. This results seems confirm the part of the literature skeptical on the presence of a relationship among attitudes, intentions and behavior (Ajzen and Fishbein 1975, Ajzen, 2005; McGuire, 1985; Kraus, 1995; Wilcock *et al.*, 2004).
In particular in this study we can find some possible explanation of the discordance. First of all the attitudinal questions asked for personal opinions towards different uses of DNA transfer techniques, while in the choice experiments people are asked to choose what they eat. Stating one's personal accordance with a question is far different from experiencing it. Perceived risk exposure in the second circumstance is greater than in the first one and, as said before, our sample revealed to be basically risk adverse.
Accordingly, our respondents probably do not trust the GM food, but their choice behavior might have been different if they were asked to purchase a GM non-food product - i.e. GM applications could receive greatest support outside the agro-food sector, as suggested by Frewer & Shepherd, 1995; Bredahl *et al.*, 1998.
The lowest price discount for GM functional yoghurt indicates that even if the general view of GMOs in the food sector is negative, their uses for enhancing the nutritional value could be more easily accepted, provided that the benefit is realistic and valuable.
The estimation of the Random Parameter Logit Model (see table 3) doesn't allow us to distinguish taste heterogeneity, i.e. to identify a GM supporters segment of demand[8]. A widespread negative attitude towards the consumption of food obtained from GMOs seems prevails.
Such opposition can be confirmed by the big discount rates required for comparing a generic GM yoghurt with a conventional one (see table 2).

6. Final remarks

Consumer concerns about food safety are an important issue that public authorities and private organizations have to deal with constantly, especially when GMOs are involved. Previous studies suggested that one of the most important factors affecting the public perception of GMOs can be identified in their perceived lack of benefits (Gaskell *et al.*,

[7] The rate is the negative ratio of each attribute to the price coefficient.
[8] The size of the sample could be one of the reasons of the inability to highlight taste heterogeneity.

2003, 2004). Thus when gene technologies are able to supply new "value added" products that respond efficiently to consumer health priorities, acceptance is likely to increase, at least in some cases (Canavari *et al*., 2005 a, 2005b).
This paper reviews and analyses this hypothesis using discrete choice methods. Results seem to highlight a strong negative attitude toward the consumption of GM food in Trentino. Accordingly, the majority of the respondents are not willing to pay money for GM yoghurts even if they offer health, price or environmental benefits.
The local context might have played a crucial role in determining such attitudes, assuming that Trentino agricultural production is generally characterized by high quality attributes. Local production practices are deeply rooted to tradition, history and other values that describe the identity of the territory. Such standards are in contrast with the image of extensive and impersonal agriculture that the gene technologies suggest.
Moreover, attitudinal questions show that risk aversion probably affected responses.
Price differences alone did not achieve any effect in terms of choosing the GM yoghurts.
However, neither environmental benefit nor health functionality seem to change consumer preferences. Results suggest that, currently, the perceived costs of the gene technology implications far outweigh the potential benefits that people could possibly gain.
Nevertheless, functional GM yoghurt received the lowest level of negative utility. Accordingly, some interaction between the kind of utility provided by the GMOs and their levels of acceptance can be seen.
An important finding deals with the stated need of deeper knowledge through the scientific research. Respondents felt that neither labels nor certification seem capable of always safeguarding consumers from hazard; thus, their presence alone does not increase confidence, while better scientific information on the risks and benefits of gene techniques seem to be required.
There is a need for more research on the issue of purchase behavior for GM food, with the aim of testing the effect on the public perceptions of different technologies available for producing such applications (i.e. "sustainable" biotechnologies) which in turn answer in a more efficient way to the social demand of safety.

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Tables

Table 1. Multinomial Logit Model for Yoghurt

Variable	*Coefficient*	*Standard Error*	*b/St.Er.*	*P[|Z|>z]*	*Mean X*
PEURO	-.9955544977 *	.54898387	-1.813	.0698	
YIELD	-2.805719625**	.19507972	-14.382	.0000	
ENV	-2.460660058 **	.21171911	-11.622	.0000	
HEALTH	-1.004661685**	.24894843	-4.036	.0001	

Statistically significant at the 0.1 level;** Statistically significant at the 0.05 level
Source: our elaboration

Table 2. Partworths associated with the GM attributes in yoghurt

Attributes	*Coefficients*	*Part-worths*
PEURO	-0,995	
YIELD	-2,806	2,818
ENV	-2,461	2,472
HEALTH	-1,005	1,009

Source: our elaboration

Table 3. Random Parameter Logit Model for Yoghurt alternatives

Variable	*Coefficient*	*Standard Error*	*b/St.Er.*	*P[|Z|>z]*	*Mean X*
Random parameters in utility functions					
PEURO	-.9903165441	.54483736	- 1.818	.0691	
YIELD	-2.828603683	.19744887	-14.326	.0000	
Nonrandom parameters in utility functions					
ENV	-2.461578129	.21133193	-11.648	.0000	
HEALTH	-1.006393893	.24991407	- 4.027	.0001	
Diagonal values in Cholesky matrix, L.					
sPEURO	.6457653781E-01	.23245424	.278	.7812	
sYIELD	.6658882037E-01	.20639151	.323	.7470	
*Below diagonal values in L matrix. V = L*Lt*					
YIELD:PEURO	.1712161138	.17350484	.987	.3237	
Standard deviations of parameter distributions					
sdPEURO	.6457653781E-01	.23245424	.278	.7812	
sdYIELD	.1837090869	.16854542	1.090	.2757	

Source: our elaboration

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Contact information

Sandra Notaro
Dipartimento di Economia
Università degli Studi di Trento
Via Inama, 5
I-38100 Trento (Italy)

Phone: +39 - 0461 88 2158
Fax: +39 - 0461 88 2222
Email: sandra.notaro@unitn.it