Research article

Econometric analysis of choice drivers and willingness to pay for certified forest biomasses for energy

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Abstract. In the field of fuels generated from renewable resources, woody biomasses have found fertile ground for labelling. Indeed, several certification schemes have been developed, covering not only the sustainability of forest management, but also the chain of custody, allowing the traceability of products at different stages, from production to purchase. This study aims to investigate whether there is a willingness to pay for forest products for energy purposes with sustainability or quality certifications (FSC, PEFC and ENplus certifications) and what determines it, using pellets as reference product for the study. To do so, an exploratory analysis has been conducted, firstly using Principal Component Analysis (PCA) for a dimensional reduction and, subsequently, an ordered logistic regression. The results show that more than 30% of consumers are mainly willing to pay up to 10% more for PEFC and FSC certified pellets than for non-certified products, indicating a strong attention by consumers towards environmental issues, the quality certifications that can be adopted for pellets, and the attitude of consumers towards local and recycled products.

Keywords: pellet, sustainability certification, willingness to pay, quality label.
JEL codes: M31.

HIGHLIGHTS

- Consumers are willing to pay a premium price for quality or sustainability-certified forest biomasses for energy purposes.
- Not only does price influence pellet consumers; label knowledge and environmentally-friendly habits are also the most significant drivers of certified pellets WTP.
- The level of knowledge about certification schemes positively influences certified pellets WTP.

1. INTRODUCTION

In recent decades, the term *bioeconomy* has been used to describe the production and trade of products derived from renewable biological resources, such as crops and forests (European Commission, 2012). Given the growth of the global population and the overconsumption of many resources, together with the ongoing climate change (Perone, 2019), the bioeconomy seems to be a solution to the scarcity of non-renewable resources, such as oil products (European Commission, 2018), and the related increase in prices, which in 2022 are reaching historical highs.

The road towards the so-called bioeconomy has been paved since the 1970s, when the environment became an issue of discussion (Welford, 1995). However, it was only in the last decades of the 20th century that the issue of sustainable production of renewable biomasses arose (Ros *et al.*, 2010). The issue has grown into a social concern and, since then, has shaped the general attitude of consumers towards sustainably-crafted products (United Nations Environment Programme, 2018). This new attitude has also put pressure on businesses to adopt environmentally sound practices (Bradley, 2021); indeed, nowadays, consumers increasingly demand that biomass production (ISPRA, 2010) complies with *minimum standards* of social and environmental responsibility (European Commission, 2018). For example, in 2020, the Italian consumption of certified quality pellets – a biofuel made of compressed untreated sawdust – reached 1.1 million tonnes out of a total of 3.4 million tonnes of national consumption, showing a marked positive trend compared to previous years (Associazione Italiana Energie Agroforestali, 2021). The same concern is expressed in many other sectors through an increase in so-called ethical consumer purchases, regarding the environmental and social spheres of products (Blanc *et al.*, 2021). Many forms of labelling have consequently been established since the late 1990s to inform consumers about the link between the product and its origin and processing phases (Paluš *et al.*, 2021). Product labelling has also been used to identify those products deriving from environmentally-friendly productions and chains of custody (Tikina, Innes, 2008). Indeed, the label is the most immediate tool to help consumers compare certified products with other non-certified ones of the same category, allowing them to express their preferences towards more sustainable consumption.

In the field of fuels generated from renewable resources, woody biomasses have found fertile ground for labelling. Indeed, several certification schemes have been developed since the end of the 20th century, covering not only the sustainability (economic, environmental and social) of forest management, but also the so-called *chain of custody*, allowing the traceability of products at different stages, from production to purchase.

Among these certification schemes, the most widely used in the field of forest sustainability are the *Forest Stewardship Council* (FSC) and the *Programme for the Endorsement of Forest Certification* (PEFC). Both apply to any forest product (and recently to forest services as well), including forest biomasses. FSC is an international, independent, non-profit organization established in 1993 to promote responsible forest management and later introduced in Italy in 2001. This certification covers 230 million of hectares and also deals with chain of custody, allowing consumers to evaluate the path of the product (FSC, 2022). PEFC is a voluntary certification that covers both the management of the forests and the chain of custody. The certification was developed in Europe in 1999 to meet the needs of wood producers and subsequently introduced in Italy in 2001. Currently PEFC certification covers more than 326 million of hectares in the world and 888,494 in Italy (PEFC, 2022).

On the other hand, in the specific field of product quality, the ENplus certification establishes technical specifications such as calorific power, durability and dust that allow for better product quality (ISO/IEC 17065:2012 — Conformity Assessment — Requirements for Bodies Certifying Products, Processes and Services, 2012), being especially dedicated to pellet fuel. This certification was established in 2011 and was based on international ISO standards but adopting more stringent requirements. Currently ENplus certifies more than 13 million tons of pellets representing the most important quality certification for this product (ENplus, 2022).

Given the widespread nature of this type of labels, several studies have investigated consumer attitudes towards certified product purchase, in particular the willingness to pay (WTP) a premium for certified wood products (Paletto, Notaro, 2018). It has been shown that consumers are willing to pay a price premium ranging from 1% to 39% of the base price for a certified product (Cai, Aguilar, 2013). In more detail, recent research has shown that, while in the past older people with a good income were the main purchasers of labelled products, in the last few years this trend has been changing and the main buyers of eco-labelled products are the younger, more environmentally-aware generations (Higgins *et al.*, 2020). Another interesting result related to the consumption of forest products is that the base price of a product is usually negatively correlated with consumers' WTP, meaning that the buyers are willing to pay a higher premium price for cheaper products (Cai, Aguilar,

2013). This result ties with Teisl (2003), who found that WTP is higher for more frequently-used products, due to the belief that frequently-purchased wood products have a greater impact on the environment. Finally, knowledge of and trust in an eco-label also influence consumers' attitudes and their WTP (Panico *et al.*, 2018), which is why companies and policy makers should implement targeted information campaigns on ecolabels and environmental issues (Panico *et al.*, 2022).

As consumer awareness and propensity to pay a price premium for labelled forest products for energy purposes is a relatively unexplored field of research, even when considering the different meanings people give to sustainability. This study aims to investigate whether there is a willingness to pay for forest products for energy purposes with sustainability or quality certifications and what determines it, using pellets as a reference product.

The choice of pellets as case study can be related to different aspects. Based on the latest specific data published on pellet utilization, this product is used by more than 4% of Italian families to heat domestic environments (ISTAT, 2014) and its consumption steadily increased from 2012 (AIEL, 2020). In particular, by considering regional aspects, pellet utilisation seems to be more important in Northern Italy, where households have twice the consumption of Central Italian households and four times that of Southern Italian households (ISTAT, 2014).

To do so, a multi-section survey was developed using Google form and subsequently shared online. Following data collection, an exploratory analysis was conducted, first using Principal Component Analysis and subsequently an ordered logistic regression to highlight different patterns of consumer perception and behaviour of sustainability, and to elicit information about the main drivers of consumer WTP.

The objective of the study was pursued by answering the following specific research questions:
1. How do consumers approach and behave about the topic of sustainability? What is their level of knowledge about sustainability and quality labels?
2. Are consumers willing to pay a premium price for a bag of pellets with a sustainability or quality certification?
3. What drives consumers' willingness to pay for this labelled forest product?

The paper is structured as follows: I) the methodology section presents how data were collected through an online survey and subsequently analysed with the *Principal Component Analysis* (PCA) and the ordered logistic regression tools; II) the results section includes the main findings about the dimensional reduction with the PCA

and the main drivers of sustainability or quality labelled pellets WTP; III) the discussion section tries to explain these main findings, like the lower quota of respondents who are willing to pay a premium price for labelled pellets, or the main determinants of WTP emerged from the ordered logistic regression, e.g., label knowledge, product origin, sustainability perception. age and level of education of purchasers; IV) finally, the conclusion section includes further research that can be developed and possible market and policy implications of the study and its main limitations.

2. METHODOLOGY

2.1. Data collection and questionnaire structure

In order to collect information about consumers' knowledge and opinion on sustainability and their pellet purchasing process, a self-compiled questionnaire was designed. It consists of three parts: the first one deals with consumers' behaviour and attitudes on sustainability and their level of knowledge on the main sustainability and quality pellet certifications. The survey was presented in the online data collection as specific to pellet consumers. To avoid response bias, a filter question was used where respondents were asked whether they were actually users of this product, if so they were redirected to the compilation

Starting from the first part, based on what is already known in the literature, several questions on the perception of sustainability were administered, as shown in Table 1. In particular, the section about sustainability perception focuses on what consumers think about environmental sustainability (attitude) and on how consumers act in relation to sustainability issues (behaviour). These two items were explored through questions based on the literature. No validated attitudinal scales were adopted, trying to build different constructs about attitude (Minton, Rose, 1997; Moser, 2016) and behaviour (Liobikiene, Juknys, 2016; Paco, Lavrador, 2017).

Regarding the evaluation of consumers' specific knowledge about the main certifications linked to sustainability (PEFC and FSC) and quality (ENplus), a three-item construct based on subjective knowledge was designed and adapted as indicated by Pieniak *et al.* (2010).

The second section focuses on the pellet purchase process and consumption, where extrinsic and intrinsic characteristics are considered, and on the WTP for sustainability certification or quality-labelled pellet bags.

The last section deals with the socio-demographic aspects of the respondents such as age, gender, education, family members and monthly household income.

Tab. 1. Constructs used in the questionnaire to explore behaviour, attitude and knowledge about sustainability.

Category	Variables	Source
Behaviour	Differentiate waste even though it is not mandatory	Liobikiene, Juknys, 2016
	Use of energy-saving light bulbs	Liobikiene, Juknys, 2016
	Short distances without a car	Paço, Lavrador, 2017
Attitude	Woody and agricultural biomass as a valuable source of energy	-
	Prefer to buy local products	Moser, 2016
	Favourable to stop buying from polluting companies	Minton, Rose, 1997
	Prefer to buy recycled products	Minton, Rose, 1997
	In favour of paying more taxes to reduce pollution	Minton, Rose, 1997
	Current environmental measures are adequate	Moser, 2016
Knowledge	ENplus level of knowledge	
	FSC level of knowledge	Adapted by Pieniak *et al.*, 2010
	PEFC level of knowledge	

All questions included in the questionnaire are closed-ended, either binary questions (Yes/No) or five-point Likert scales, where 1 means "Not important/Never/Totally disagree" and 5 means "Very important/Very often/Totally agree" depending on the specific context.

The questions dealing with the WTP for PEFC, FSC or ENplus labelled pellets are structured with five different options, starting from a base price of 4.50 €/bag: 0%, up to 10%, up to 20%, up to 30% and more than 30% of the base price.

The questionnaire, which was written using easily understandable terminology, was first tested with a user panel and then distributed online, using the Google Form tool. To reach as many consumers and interested people as possible, it was shared through specialised forums and social media, during the period between 2020 and 2021, collecting 254 valid interviews which were then coded and recorded in a database. Socio-demographic characteristics of the Italian consumers interviewed are reported in Table 2.

In order to group the observations into different age cohorts, the classification proposed by Brosdahl, Carpenter (2011) was adopted, resulting in the following categories: Younger generations (between 1982 and 2000, also including those few people born after 2001), Generation X (between 1961-1981) and Older generations (between 1925 and 1960, grouping the Baby boomers and Silent generation cohorts).

2.2. Principal Component Analysis

The next step in the analysis was the simplification of the dataset, in order to reduce the number of covariates, through a PCA. This procedure performs a

Tab. 2. Socio-demographic characteristics of the sample (n=254).

Variables	Category	Frequency (n)	Percentage
Gender	Male	156	*61.42*
	Female	98	*38.58*
Age cohort	Younger generations	112	*44.10*
	Generation X	101	*39.76*
	Older generations	41	*16.14*
Family members	1-2	92	*36.22*
	3-4	133	*52.36*
	>4	29	*11.42*
Educational level	Elementary and middle school	35	*13.78*
	High school	126	*49.60*
	University	69	*27.17*
	Higher education	24	*9.45*
Monthly household income (€)	Up to 2000	68	*26.77*
	2001-3000	81	*31.89*
	3001-4000	40	*15.75*
	> 4000	19	*7.48*
	No answer	46	*18.11*

dimensional reduction of the data with a slight loss of explained variance (Gewers *et al.*, 2021). Moreover, it can highlight any latent relationships between the included covariates, grouping them into a new set of orthogonal variables (Capitello *et al.*, 2016) and making the information level more effective.

The 12 original variables included in the analysis are those reported in Table 3, which refer to consumer behaviour and attitude towards sustainability in a comprehensive view, and to the subjective knowledge of the main labels used to assess the sustainability or quality of pellets.

Tab. 3. Variables included in the Principal Component Analysis (n=254).

Category	Variables	Mean	St. dev.
Behaviour	Differentiate waste even though it is not mandatory	4.44	0.95
	Use of energy-saving light bulbs	4.38	0.85
	Short car-free distances	3.99	1.17
Attitude	Woody and agricultural biomass as a valuable source of energy	4.28	1.01
	Prefer to buy local products	3.94	0.98
	Favourable to stop buying from polluting companies	3.73	1.17
	Prefer to buy recycled products	3.35	1.12
	In favour of paying more taxes to reduce pollution	3.13	1.33
	Current environmental measures are adequate	1.86	1.03
Knowledge	ENplus level of knowledge	2.85	1.57
	FSC level of knowledge	2.63	1.41
	PEFC level of knowledge	2.31	1.33

Only principal components (PCs) with eigenvalues greater than 1 were considered for further analyses, as factors with a lower value could be considered unreliable (Kaiser, 1960; Cliff, 1988). Finally, Varimax rotation was implemented to simplify the interpretation of the results (Kaiser, 1958; Abdi, Williams, 2010). Thus, results and subsequent discussions will refer to rotated factor scores with a value greater than |0.400|, which is considered appropriate for the sample size of the dataset (Hair *et al.*, 1998; Pituch, Stevens, 2012).

The last step of the dimensional reduction procedure involves the adequacy and reliability tests. To check whether the sample size is adequate, the Kaiser-Meyer-Olkin (KMO) test was used: results up to 0.600 are considered reliable (Kaiser, Rice, 1974). Secondly, Bartlett's sphericity test was applied to check whether the correlation matrix is adequate for carrying out factor analysis (Dziuban, Shirkey, 1974).

Finally, Guttman's lambda test was implemented to check the internal consistency of the factors and of the overall model (Gliem, Gliem, 2003). Internal consistency coefficients below 0.600 are considered inadequate to be used in subsequent analyses; therefore, similarly to Giampietri *et al.* (2016) PCs with similar values will be excluded.

2.3. Ordered logistic regressions

To estimate how the willingness to pay a premium price for the bag of pellets with a sustainability or quality label, was performed through a series of ordered logistic regressions, one for each proposed label (FSC, PEFC, ENplus), similarly to what has been done in recent studies (Capitello *et al.*, 2016; Merlino *et al.*, 2020; Giampietri *et al.*, 2021).

The ordered logistic regression implies that the observed ordinal dependent variable Y is a function of another latent variable, Y^*, which is unobserved and continuous (Wooldridge, 2012). The values of Y^* will be compared with the different cut points calculated by the model, highlighting the probability that the observation falls into one specific ordinal category or another (Williams, Quiroz, 2020). The ordinal dependent variable is the willingness to pay (WTP) a premium price for a pellet bag with a sustainability or quality label, with five responses ranked (1-5), as reported in section 2.1.

Only the sign of the coefficients obtained from the model estimation can be discussed directly: in order to highlight the magnitude of the covariates, odds ratios were calculated.

The ordered logistic function, derived from the model, is structured as follows (1):

$$Y_i^* = \alpha\, PC1\ldots n_i + \lambda Sociodemographics_i + \sigma Intr/Extr\_char_i + \varepsilon_i \qquad (1)$$

where Y_i^* is the latent variable for the i observations, $PC_{1\ldots n}$ are the factors obtained from the PCA deemed suitable for the logistic analysis, *Sociodemographics* corresponds to the variables Age cohort, Gender, Family members, Education, Monthly household income, and *Intr/Extr_char* are the intrinsic/extrinsic attributes of pellets, reported in Table 4, considered by consumers during the purchase process. Finally, ε_i is the stochastic error.

The goodness of fit of the three models was estimated through the *Pseudo R²* value, whereas the proportional odds assumption of the ordered logistic regression was tested through the likelihood-ratio test (Mehmetoglu, Jakobsen, 2017; Giampietri *et al.*, 2021).

Tab. 4. Attributes included in the ordered logistic regression (n=254).

Variables	Mean	St. dev.
Price	4.13	1.05
Wood species	3.51	1.55
Absence of Residue	3.13	1.28
Local origin	2.68	1.42
Label	2.37	1.42

All the analyses were performed using STATA 17.0-SE (StataCorp, 2021) statistical software.

3. RESULTS

The descriptive analysis of WTP a premium price for certified pellets by consumers in Table 5 allows some preliminary considerations to be made. First of all, it is evident that most of the respondents are not willing to pay an additional premium for sustainability certifications compared to ENplus certification. Furthermore, more than 30% of consumers are mainly willing to pay up to 10% more for PEFC and FSC certified pellets than for non-certified products. ENplus, compared to sustainability certifications, has fewer consumers willing to pay up to 10% or not willing to pay, in favour of the classes with higher WTP. From these descriptive considerations, it can be deduced that quality certification is slightly more appreciated by consumers.

3.1. Principal Component Analysis

With the adoption of the PCA, a dimension reduction was obtained starting from the original twelve regressors (Table 3) and obtaining a four PCs model, whose characteristics are presented in Table 6. The principal components, as indicated in the methodology earlier, represent a new set of variables obtained by saving

Tab. 5. Frequency distribution of Consumers' willingness to pay for certified pellets.

	PEFC	FSC	ENplus
0%	48.8	45.7	41.3
up to 10%	31.9	35.0	29.5
up to 20%	15.0	14.2	21.7
up to 30%	3.5	4.3	5.5
more than 30%	0.8	0.8	2.0

most of the variance carried by the original variables; in particular, the model explains 58% of the total variance. The adequacy was met on the basis of the significance of Bartlett's test and value of the KMO test higher than 0.6. However, to select suitable components for the regression analysis, a second step was conducted to check the consistency of the grouped variables, using Guttman's lambda test. This analysis indicates that three components were sufficiently reliable (PC1; PC2; PC3), while the fourth was excluded at this stage. Table 6 shows, in addition to the PCs, the results of the model adequacy and reliability tests as well as Guttman's lambda for internal factor consistency.

The first PC explains 19.2% of the total variance and groups together many variables related to the approach to sustainability, indicating a strong attention of consumers towards environment issues. This consideration stems from the combination of the factor loading of the variables; in fact, from the coefficients, a positive correlation can be observed between the *differentiation of waste, even if not mandatory*; the *preference for walking rather than using a car for short distances*, the *purchase of recycled products*, the *propensity to pay more environmental taxes*, the *attitude toward biomasses* and *to avoid products from polluting companies*. This combination suggests that consumers may associate multiple aspects that contribute to environmental sustainability. Indeed, for the respondents such aspects can be combined in a new factorial dimension. They recognise a certain complexity in the sustainability issue that can be addressed on the basis of several combined actions, such as waste separation and environmental taxes. Based on these considerations and on the number of variables correlated, the PC can be related to broad attention to the main aspects of sustainability, the name *Holistic approach to sustainability* was chosen for this component.

The second dimension accounts for 16.4% of the variance derived by the original covariates. This PC collected the variables related to knowledge of the certification schemes, in particular, the self-reported knowledge of FSC, PEFC and ENplus certifications. As expected, the positive coefficients of the original variables indicated a certain degree of correlation between consumer knowledge of sustainable and quality certifications that can be adopted for pellets by providing a strong factorial dimension including just the variables related to consumer knowledge. The relationship described by the component suggests that there is some degree of association between the certifications, indicating that informed consumers are likely to be familiar with more than one certification scheme. Furthermore, the association between PEFC and FSC is stronger compared to ENplus, probably because these certifications

Tab. 6. Results of the Principal Component Analysis.

Variables	PC 1	PC 2	PC 3	PC 4
Differentiate waste even though it is not mandatory	0.547			
Short distances without a car	0.472			
Use of energy-saving light bulbs			0.867	
Prefer to buy local products			0.559	
Prefer to buy recycled products	0.536		0.426	
In favour of paying more taxes to reduce pollution	0.743			
Woody and agricultural biomass as a valuable source of energy	0.453			0.493
Favourable to stop buying from polluting companies	0.721			
Current environmental measures are adequate				0.721
PEFC level of knowledge		0.907		
FSC level of knowledge		0.858		
ENplus level of knowledge		0.513		0.477
Bartlett's test of sphericity	Chi-square = 614.225		Df = 66	Sig = 0.000
KMO's test	0.685			
Guttman's lambda (PCs)	0.709	0.680	0.603	0.201
Guttman's lambda (Overall model)	0.717			

* Only factor loadings > |0.400| were considered for the analysis.

are both related to sustainability aspects and in the mind of consumers a certain degree of overlapping of confusion between them may occur. Concerning the ENplus that deals mainly with quality aspects, the relation found with the other variables related to FSC and PEFC indicate that correlation exists between quality and sustainability aspects. For these reasons the PC was named *Subjective knowledge of sustainability and quality labels*.

The last PC considered reliable – on the basis of the internal consistency test – explains a total of 12.8% of the variance. It contains the variables related to sustainable energy use (*using energy-saving light bulbs*) and to the *purchase of sustainable products*, due to the attitude toward local and recycled products. Factor loadings indicate a positive relationship among these elements, suggesting that the use of sustainable energy and the attitude towards local and recycled products are tied, probably because the latter are also related to saving energy and resources, with positive impacts on environmental sustainability. In fact, this PC is mainly related to the purchasing intention of sustainable products and the avoiding of energy waste. Considering these aspects, this component was named *Sustainability linked to purchasing and consumption habits*.

3.2. Ordered logistic regressions

As indicated in the methodology, three different ordered logistic regressions were performed to highlight which drivers affect the WTP an additional premium price for certified pellets and whether there are differences between the models, as shown in Table 7.

Starting with the PCs used as covariates, *Holistic approach to sustainability* and *Subjective knowledge of sustainability and quality labels* were significant in each regression. The component *Sustainability linked to purchasing and consumption habits* was only significant when describing WTP for PEFC certified products. These results suggest that both knowledge of certifications and environmental concern are important in placing a higher value on products bearing sustainable or quality certifications, particularly for PEFC certifications, since the PCs related to environmental attitude were both significant only in this regression.

Moving on to socio-demographic predictors, the age cohort was negatively related to the additional premium price for PEFC, FSC and ENplus, suggesting that older people are less interested in these certifications. The odds ratio quantified this attitude in terms of probability ratio, indicating that older people are 0.662 times less willing to pay for PEFC, 0.668 for FSC and 0.722 for ENplus. Gender was positive and significant in PEFC and FSC models, indicating that women are more interested in such certifications and willing to pay more for them, respectively 1.935 time more and 1.859 times more. Education level is positively related with FSC certification, with more educated people being 1.479 times more willing to pay a premium price for pellet-bearing FSC.

Tab. 7. Ordered logistic regression results (n=254).

Covariates	PEFC			FSC			ENplus		
	Coef.	Odds ratio		Coef.	Odds ratio		Coef.	Odds ratio	
PC 1	0.529	1.697	***	0.531	1.701	***	0.459	1.582	***
PC 2	0.559	1.749	***	0.550	1.734	***	0.286	1.332	**
PC 3	0.264	1.302	*	0.222	1.248		0.156	1.168	
Age cohort	-0.413	0.662	**	-0.403	0.668	**	-0.326	0.722	*
Gender	0.660	1.935	**	0.620	1.859	**	0.366	1.442	
Family members	0.001	1.001		0.037	1.038		-0.065	0.937	
Education level	0.226	1.254		0.391	1.479	*	0.199	1.220	
Monthly household income	0.021	1.021		-0.020	0.98		0.198	1.219	*
Wood species	0.055	1.057		0.028	1.029		-0.038	0.963	
Price	-0.216	0.806	*	-0.120	0.887		-0.206	0.814	*
Local origin	0.175	1.191	*	0.203	1.225	**	-0.074	0.920	
Label	-0.019	0.981		-0.049	0.952		0.125	1.133	
Absence of residue	0.040	1.040		0.067	1.069		0.152	1.164	
/cut 1	-0.022			0.514			-0.365		
/cut 2	1.798			2.508			1.093		
/cut 3	3.583			4.120			2.866		
/cut 4	5.356			6.083			4.302		
Log-pseudolikelihood	-257.491			-260.652			-301.248		
Chi-square	62.13			64.75			52.17		
prob. Chi-square	0.000			0.000			0.000		
Pseudo R^2	0.123			0.128			0.083		

p-value levels of significance * < 0.1; ** < 0.05; *** < 0.01.

Turning to pellet attributes, price was significant in PEFC and ENplus models, suggesting that people who place more importance on price are less willing to pay for these certifications. Another insight related to this outcome suggests that PEFC and ENplus buyers are more price sensitive than people interested in FSC. Finally, the role of local origin was only significant for sustainability certifications schemes. This result suggests a relationship between these certifications and the importance attached to the origin of timber, indicating that the role of PEFC and FCS is at least partially recognised by consumers.

4. DISCUSSION

Woody biomass has been recognised as an important element in combating the climate crisis and promoting renewable energy, since – in addition to being the main source of bioenergy in the EU (Šupín *et al.*, 2019) – its emissions appear to be climate neutral (Luick *et al.*, 2022). Among the woody biomass products, pellets have gained strong interest in the global market,

becoming one of the best-selling products, as reported by Nuramin *et al.* (2020).

Given the increasing volume of pellet imports from non-EU countries, such as the United States (Fingerman *et al.*, 2019), and the high exploitation of forests to meet the high market demand (Luick *et al.*, 2022), the importance of introducing eco-labels that guarantee the quality, origin and sustainability of the product seems evident.

Based on these considerations, this study tried to investigate the demand side, the WTP a premium price, and the factors that motivate a consumer to buy a bag of certified pellets.

Three key findings emerged in the light of our analysis:

1. concerning the perception of sustainability by pellet consumers, three clear components emerge. A first component based more on attitudes and defined as a *Holistic approach to sustainability* in which a strong focus on environmental issues, their complexity and actions to face them emerges. In the literature, several authors state that environmentally-conscious consumers are positively inclined to buy green prod-

ucts (Chaudhary, Bisai, 2018; Carfora *et al.*, 2019; Rahman *et al.*, 2020). A second component linked to knowledge of the certification schemes adopted in this study and named *Subjective knowledge of sustainability and quality labels* was highlighted. In a study by Tan *et al.* (2019) on Chinese consumers' preferences in purchasing certified wood flooring, the importance of knowledge of eco-labels was recognised. Finally, a last component called *Sustainability linked to purchasing and consumption habits* in which sustainable behaviours emerge, such as the purchase of recycled, local and sustainable products and a responsible and sparing use of energy was identified.

2. Almost half of the consumers are not willing to pay a premium price for the three certifications analysed. About 30% would be willing to pay 10% more than the base price and only a small fraction would be willing to pay more than 20%, more for quality certification than for sustainability. Although the WTP varies depending on the products studied and the location under analysis (Wan *et al.*, 2018), the obtained WTP ranges for certified pellets remains consistent with those reported in the meta-analysis of Cai, Aguilar (2013) for certified forest products, that is between 1 and 39%. This result, which is in contrast to the statement made by Vásquez Lavin *et al.* (2020) on the low possibility of paying a premium price for certified forest products, is also in line with the findings of García *et al.* (2021) for firewood, suggesting that it is forest products intended for energy use that are susceptible to a premium price.

3. The factors leading consumers to pay a premium price for a bag of certified pellets are multiple and are to be found in some components of the perception of sustainability, such as attention to environmental issues and knowledge of labels. Notaro, Paletto (2021) in a study conducted on the WTP, attitudes and preferences of Italian consumers towards wood fibre bio-textile report that environmental issues are among the main drivers of green purchasing behaviour. Concerning label knowledge, Panico *et al.* (2022) in a study conducted on the purchasing behaviour of Italian consumers for certified forest products, state that certification has a positive effect on the WTP, while they had no significant results concerning the factors "trust" and "environmental attitude" of consumers. Other factors that lead consumers to pay a premium price for certified pellets are found in the sociodemographic domain. Our results partly support what Higgins *et al.* (2020) stated about sociodemographic predictors

of WTP for eco-labelled forest products. Indeed, age, particularly youth, and level of education are key predictors. Indeed, age, in particular the younger generation, and level of education are strong predictors of consumer behaviour since they were significant in all models. Gender is a good predictor of behaviour only for sustainability certifications while income was not significant in the models. In the literature, however, Zhang, Dong (2020) report that women are more likely to make green purchases and several authors of studies on the use of alternative energy sources for households have emphasised the importance of income as a key variable for WTP (Streimikiene *et al.*, 2019; García *et al.*, 2021; Nduka, 2021). Finally, pellet attributes such as local origin for sustainability certifications and price for PEFC and ENPlus certifications are also important factors for the WTP of certified pellets. Specifically, our results show a negative relationship between price and WTP, in fact the lower the price, the higher the propensity to purchase the certified product, thus agreeing with a study by Luo *et al.* (2018) on Chinese and Japanese consumers' willingness to pay for modern wood structures, according to which the base price of the product influences the consumer's WTP. This result can probably be attributed to the fact that pellets are a non-durable good.

5. CONCLUSIONS

5.1. Main findings

The objective of this study was to explore if, and how, consumers attach importance to different sustainability and quality labels about woody biomasses for energy purposes, and whether this importance translates into a willingness to pay for such attributes. To do so, three research questions were proposed, focusing on the pellets market.

Concerning the first one, the results highlighted a certain propensity of consumers towards an ecological behaviour and attitude, considering both their daily actions and their opinion on energy consumption and pollution. Despite their positive leanings, consumers also declared a relatively average level of knowledge on the sustainability and quality certifications of forest products proposed in the study (PEFC, FSC and ENplus), suggesting that they do not distinguish the labels and their meanings well.

Focusing on the second research question, the majority of respondents are not willing to pay a premium price for a bag of sustainable or quality labelled

pellets. Among those who are in favour of paying more for a certified product, it seems that both sustainability labels behave similarly, again confirming the scarce differentiation between PEFC and FSC by consumers; moreover, the quality scheme received a higher WTP than the others, considering the increasing importance given by buyers to quality standards.

After confirming the presence of a quota of consumers willing to pay a premium price, the third research question tried to explore the main drivers of this answer. What emerges is that label knowledge and approach to sustainability positively influence the propensity to pay a premium price, particularly in the case of PEFC. Turning to socio-demographics data, age cohort, and gender were the most relevant, followed by education level and monthly household income (significant for only one label respectively). Finally, considering the characteristics of the product, only price and local origin were found to play a role in WTP.

5.2. Limitations and future research

The main limitation of the study is linked to the national dimension of the survey: although the sample is adequate for the analysis conducted and is also representative of the Italian situation, it does not reflect the international scene, due to the difficulty of comparing different markets and consumers. In this direction, further research could increase the scientific reliability of this analysis, by adopting an international scale in the survey of woody biomass purchasers.

The second issue that can be improved regards the method of investigation of the willingness to pay. In fact, the present research performed a deeper analysis on the drivers of WTP, and further studies on the premium prices that purchasers give to certified forest biomasses like pellets are needed. In this way other econometric tools like choice models or experimental auctions could be implemented on the certified pellets market.

Moreover, the issue related to the evaluation of sustainability and environmental friendliness has been explored by adopting different literature sources: further research could implement validated psychometric scales, obtaining a more reliable estimation of consumer attitudes. In fact, the adoption of constructs or attitudinal scales already validated in the literature and implemented with a confirmatory factor analysis could enrich further in-depth studies, better highlighting the role of consumer's behaviour, attitude, and knowledge spheres on forest biomasses' WTP. Likewise, Principal Component Analysis is not supported by a structured model including latent constructs, as in the case of Exploratory

or Confirmatory Factor Analysis, making the interpretation of the components more difficult. In this direction, the methodology approach itself could be improved, e.g., by the adoption of the Partial Least Squares Structural Equation Modelling (PLS-SEM) technique, to better explore complex structural models with more detailed cause-effect relationships.

Finally, among the further developments of this exploratory study, there is also the link between safety of pellet stoves emissions and quality certifications of the product. An in-depth exploration of consumers' awareness of health risks of emissions and the quality of forest biomasses could provide a more comprehensive scenario about forest biomasses market dynamics and requirements.

5.3. Market and policy implications

This is one of the first times that the drivers of willingness to pay for certified forest biomasses for energy purposes are assessed through an econometric model.

The market implications could be relevant given that almost 40% of people are not willing to pay an additional premium for certifications, companies could invest in consumer awareness and knowledge of the environmental implications of PEFC, FSC and ENplus. This is particularly interesting in the case of quality labels, since consumers seem to be more sensitive to product quality and safety standards. The adoption of private certifications could meet people's requirements for quality and, at the same time, could increase the company's economic margins.

The study also highlighted that there is not enough differentiation between the different meanings of the certifications. Policy makers can act in this direction by promoting the adoption of and knowledge on sustainable and quality certification schemes, enhancing people's environmental awareness and helping forestry and energy companies that are adopting private labels on the final product or that are certifying their production chain. From the long-term perspective, this awareness-rising action could also promote the adoption of sustainable production criteria at an international level, with positive environmental and economic repercussions on a larger scale. Finally, the question of the large-scale use of pellets and their origin acquires even greater relevance in this historic moment of energy crisis and the considerable increase in heating costs. The price on the market, which has reached peaks of 10 €/bag during the second half of 2002, is an indication of the greater prominence that this forest biomass is acquiring as a substitute for gas heating, but it could lead to less control, and there-

fore less sustainability of the supply chain and safety standards, of the material marketed, with possible repercussions for consumers in both economic and health terms.

REFERENCES

Abdi H., Williams L.J. (2010). Principal component analysis. *Wiley Interdisciplinary Reviews: Computational Statistics*, 2(4): 433-459. DOI: https://doi.org/10.1002/WICS.101

AIEL (2020). *Agriforenergy - Rivista Tecnica per l'energia rinnovabile dall'agricoltura e dalle foreste*. https://www.aielenergia.it/public/pubblicazioni/A4E_4-2020.pdf.

Associazione Italiana Energie Agroforestali (2021). *Agriforenergy - Rivista Tecnica per l'energia rinnovabile dall'agricoltura e dalle foreste*. *XV*(1). https://www.aielenergia.it/paginaSfogliabile.php?num=1_2021

Blanc S., Zanchini R., di Vita G., Brun F. (2021). The role of intrinsic and extrinsic characteristics of honey for Italian millennial consumers. *British Food Journal*, 123(6): 2183-2198. DOI: https://doi.org/10.1108/BFJ-07-2020-0622/FULL/XML

Bradley P. (2021). An Institutional Economics Framework to Explore Sustainable Production and Consumption. *Sustainable Production and Consumption*, 27: 1317-1339. DOI: https://doi.org/10.1016/J.SPC.2021.02.035

Brosdahl D.J.C., Carpenter J.M. (2011). Shopping orientations of US males: A generational cohort comparison. *Journal of Retailing and Consumer Services*, 18(6): 548-554. DOI: https://doi.org/10.1016/J.JRETCONSER.2011.07.005

Cai Z., Aguilar F.X. (2013). Meta-analysis of consumer's willingness-to-pay premiums for certified wood products. *Journal of Forest Economics*, 19(1): 15-31. DOI: https://doi.org/10.1016/J.JFE.2012.06.007

Capitello R., Agnoli L., Begalli D. (2016). Drivers of high-involvement consumers' intention to buy PDO wines: Valpolicella PDO case study. *Journal of the Science of Food and Agriculture*, 96(10): 3407-3417. DOI: https://doi.org/10.1002/JSFA.7521

Carfora V., Cavallo C., Caso D., del Giudice T., de Devitiis B., Viscecchia R., Nardone G., Cicia G. (2019). Explaining consumer purchase behavior for organic milk: Including trust and green self-identity within the theory of planned behavior. *Food Quality and Preference*, 76: 1-9. DOI: https://doi.org/10.1016/J.FOODQUAL.2019.03.006

Chaudhary R., Bisai S. (2018). Factors influencing green purchase behavior of millennials in India. *Management of Environmental Quality: An International Journal*, 29(5): 798-812. DOI: https://doi.org/10.1108/MEQ-02-2018-0023/FULL/XML

Cliff N. (1988). The Eigenvalues-Greater-Than-One Rule and the Reliability of Components. *Psychological Bulletin*, 103(2): 276-279. DOI: https://doi.org/10.1037/0033-2909.103.2.276

Dziuban C.D., Shirkey E.C. (1974). When is a correlation matrix appropriate for factor analysis? Some decision rules. *Psychological Bulletin*, 81(6): 358-361. DOI: https://doi.org/10.1037/H0036316

ENplus (2022). *ENPlus certification*. https://enplus-pellets.eu/it/

European Commission (2012). *Innovating for sustainable growth: a bioeconomy for Europe*. https://op.europa.eu/en/publication-detail/-/publication/1f0d8515-8dc0-4435-ba53-9570e47dbd51

European Commission (2018). Review of the 2012 European Bioeconomy Strategy - Publications Office of the EU. In *Publication Office*. https://data.europa.eu/doi/10.2777/8814

Fingerman K.R., Nabuurs G.J., Iriarte L., Fritsche U.R., Staritsky I., Visser L., Mai-Moulin T., Junginger M. (2019). Opportunities and risks for sustainable biomass export from the south-eastern United States to Europe. *Biofuels, Bioproducts and Biorefining*, 13(2): 281-292. DOI: https://doi.org/10.1002/BBB.1845

FSC (2022). *Forest Stewardship Council*. https://www.pefc.it

García L.Y., Cerda A.A., Lagos R. del P., Muñoz P.I., Muñoz M. (2021). Society's Willingness to Pay for Certified Dry Firewood Energy in Chile. *Frontiers in Energy Research*, 9: 271. DOI: https://doi.org/10.3389/FENRG.2021.676654/BIBTEX

Gewers F.L., Ferreira G.R., de Arruda H.F., Silva F.N., Comin C.H., Amancio D.R., Costa L.D.F. (2021). Principal Component Analysis. *ACM Computing Surveys (CSUR)*, 54(4). DOI: https://doi.org/10.1145/3447755

Giampietri E., Bugin G., Trestini S. (2021). On the association between risk attitude and fruit and vegetable consumption: insights from university students in Italy. *Agricultural and Food Economics 2021*, 9(1): 1-16. DOI: https://doi.org/10.1186/S40100-021-00194-4

Giampietri E., Finco A., del Giudice T. (2016). Exploring consumers' behaviour towards short food supply chains. *British Food Journal*, 118(3): 618-631. DOI: https://doi.org/10.1108/BFJ-04-2015-0168/FULL/XML

Gliem J.A., Gliem R.R. (2003). Calculating, Interpreting, and ReportingCronbach's Alpha Reliability Coef-

ficient for Likert-Type Scales. *Midwest Research to Practice Conference in Adult, Continuing, and Community Education.*

Hair J.F., Tatham R.L., Anderson R.E., Black W. (1998). *Multivariate Data Analysis: International Edition* (Pearson, Ed.; 5th Edition). https://www.pearson.com/uk/educators/higher-education-educators/program/Hair-Multivariate-Data-Analysis-International-Edition-5th-Edition/PGM547615.html

Higgins K., Hutchinson W.G., Longo A. (2020). Willingness-to-Pay for Eco-Labelled Forest Products in Northern Ireland: An Experimental Auction Approach. *Journal of Behavioral and Experimental Economics*, 87, 101572. DOI: https://doi.org/10.1016/J.SOCEC.2020.101572

ISO/IEC 17065:2012 - Conformity assessment — Requirements for bodies certifying products, processes and services, 1 (2012). https://www.iso.org/standard/46568.html

ISPRA (2010). *Studio sull'utilizzo di biomasse combustibili e biomasse rifiuto per la produzione di energia.* https://www.isprambiente.gov.it/files/pubblicazioni/rapporti/Rapporto1112010bassa.pdf

ISTAT (2014). *L'indagine Istat sui consumi energetici delle famiglie: Principali risultati.* https://www4.istat.it/it/files/2014/12/Ungaro.pdf

Kaiser H.F. (1958). The varimax criterion for analytic rotation in factor analysis. *Psychometrika 1958*, 23(3): 187-200. DOI: https://doi.org/10.1007/BF02289233

Kaiser H.F. (1960). The Application of Electronic Computers to Factor Analysis: *Educational and Psychological Measurement*, 20(1): 141-151. DOI: https://doi.org/10.1177/001316446002000116

Kaiser H.F., Rice J. (1974). Little Jiffy, Mark Iv: *Educational and Psychological Measurement*, 34(1): 111-117. DOI: https://doi.org/10.1177/001316447403400115

Liobikiene G., Juknys R. (2016). The role of values, environmental risk perception, awareness of consequences, and willingness to assume responsibility for environmentally-friendly behaviour: the Lithuanian case. *Journal of Cleaner Production*, 112(2016): 3413-3422. DOI: https://doi.org/10.1016/j.jclepro.2015.10.049

Luick R., Hennenberg K., Leuschner C., Grossmann M., Jedicke E., Schoof N., Waldenspuhl T. (2022). Primeval, natural and commercial forests in the context of biodiversity and climate protection: Part 2: The Narrative of the Climate Neutrality of Wood as a Resource. *Naturschutz Und Landschaftsplanung*, 54(1): 22-35. DOI: https://doi.org/10.1399/NUL.2022.01.02.E

Luo W., Mineo K., Matsushita K., Kanzaki M. (2018). Consumer willingness to pay for modern wooden structures: A comparison between China and Japan. *Forest Policy and Economics*, 91: 84-93. DOI: https://doi.org/10.1016/J.FORPOL.2017.12.003

Mehmetoglu M., Jakobsen T.G. (2017). *Applied Statistics using STATA: a guide for the Social Sciences* (S. Jai, Ed.; First edition). SAGE Publications LTD.

Merlino V.M., Brun F., Versino A., Blanc S. (2020). Milk packaging innovation: Consumer perception and willingness to pay. *AIMS Agriculture and Food 2020,* 5(2): 307-326. DOI: https://doi.org/10.3934/AGRFOOD.2020.2.307

Minton A.P., Rose R.L. (1997). The Effects of Environmental Concern on Environmentally Friendly Consumer Behavior: An Exploratory Study. *Journal of Business Research*, 40(1): 37-48. DOI: https://doi.org/10.1016/S0148-2963(96)00209-3

Moser A.K. (2016). Consumers' purchasing decisions regarding environmentally friendly products: An empirical analysis of German consumers. *Journal of Retailing and Consumer Services*, 31: 389-397. DOI: https://doi.org/10.1016/J.JRETCONSER.2016.05.006

Nduka E. (2021). How to get rural households out of energy poverty in Nigeria: A contingent valuation. *Energy Policy*, 149, 112072. DOI: https://doi.org/10.1016/J.ENPOL.2020.112072

Notaro S., Paletto A. (2021). Consumers' preferences, attitudes and willingness to pay for bio-textile in wood fibers. *Journal of Retailing and Consumer Services*, 58, 102304. DOI: https://doi.org/10.1016/J.JRETCONSER.2020.102304

Nuramin M.J., Saadun N., Harun Z. (2020). Status and development prospect of fuel pellet industry in Malaysia. *The Malaysian Forester*, 83(2): 353-371.

Paço A., Lavrador T. (2017). Environmental knowledge and attitudes and behaviours towards energy consumption. *Journal of Environmental Management*, 197: 384-392. DOI: https://doi.org/10.1016/J.JENVMAN.2017.03.100

Paletto A., Notaro S. (2018). Secondary wood manufactures' willingness-to-pay for certified wood products in Italy. *Forest Policy and Economics*, 92: 65-72. DOI: https://doi.org/10.1016/J.FORPOL.2018.04.002

Paluš H., Krahulcová M., Parobek J. (2021). Assessment of Forest Certification as a Tool to Support Forest Ecosystem Services. *Forests 2021,* 12(3): 300. DOI: https://doi.org/10.3390/F12030300

Panico T., Caracciolo F., Furno M. (2022). Analysing the consumer purchasing behaviour for certified wood products in Italy. *Forest Policy and Economics*, 136, 102670. DOI: https://doi.org/10.1016/J.FORPOL.2021.102670

Panico T., Pagnani T., Caracciolo F. (2018). Intention to Purchase Sustainable Wood Products: An Empirical

Analysis of the Determinants. *International Journal on Food System Dynamics*, 9(4): 342-353. DOI: https://doi.org/10.22004/AG.ECON.277727

PEFC (2022). *Programme For The Endorsement of Forest Certification schemes*. https://www.pefc.it

Perone G. (2019). Economic growth and GHG reduction: a global issue. *Italian Review of Agricultural Economics*, 74(1): 19-31. DOI: https://doi.org/10.13128/REA-25477

Pieniak Z., Aertsens J., Verbeke W. (2010). Subjective and objective knowledge as determinants of organic vegetables consumption. *Food Quality and Preference*, 21(6): 581-588. DOI: https://doi.org/10.1016/J.FOODQUAL.2010.03.004

Pituch K.A., Stevens J.P. (2012). Applied Multivariate Statistics for the Social Sciences : Analyses with SAS and IBM's SPSS, Sixth Edition. In *Applied Multivariate Statistics for the Social Sciences: Analyses with SAS and IBM's SPSS, Sixth Edition* (5th edition). Routledge. DOI: https://doi.org/10.4324/9781315814919

Rahman M., Aziz S., Hughes M. (2020). The product-market performance benefits of environmental policy: Why customer awareness and firm innovativeness matter. *Business Strategy and the Environment*, 29(5): 2001-2018. DOI: https://doi.org/10.1002/BSE.2484

Ros J.P.M., Overmars K.P., Stehfest E., Prins A.G., Notenboom J., van Oorschot M. (2010). *Identifying the indirect effects of bio-energy production* (Vol. 1). Netherlands Environmental Assessment Agency. www.pbl.nl/en.

StataCorp (2021). *Stata17* (No. 17). StataCorp LLC.

Streimikiene D., Balezentis T., Alisauskaite-Seskiene I., Stankuniene G., Simanaviciene Z. (2019). A Review of Willingness to Pay Studies for Climate Change Mitigation in the Energy Sector. *Energies 2019,* 12(8): 1481. DOI: https://doi.org/10.3390/EN12081481

Šupín M., Loučanová E., Olšiaková M. (2019). Sustainable bioenergy policy for the period after 2020. *12th International Scientific Conference Digitalisation and Circular Economy: Forestry and Forestry Based Industry Implications.* http://www.woodema.org/2019_conference.html

Tan Q., Imamura K., Nagasaka K., Inoue M. (2019). Effects of Eco-Label Knowledge on Chinese Consumer Preferences for Certified Wood Flooring: A Case Study in Chongqing City. *Forest Products Journal*, 69(4): 329-336. DOI: https://doi.org/10.13073/FPJ-D-19-00017

Teisl M.F. (2003). What We May Have Is a Failure to Communicate: Labeling Environmentally Certified Forest Products. *Forest Science*, 49(5): 668-680. DOI: https://doi.org/10.4324/9781351154529-28

Tikina A.V., Innes J.L. (2008). A framework for assessing the effectiveness of forest certification. *Canadian Journal of Forest Research*, 38(6): 1357-1365. DOI: https://doi.org/10.1139/X08-011/ASSET/IMAGES/X08-011T2H.GIF

United Nations Environment Programme (2018). *Buying for a Better World A Guide on Sustainable Procurement for the UN System ITC International Training Centre* (Vol. 1). https://www.ungm.org/Areas/Public/Downloads/BFABW_Final_web.pdf

Vásquez Lavin F., Barrientos M., Castillo Á., Herrera I., Ponce Oliva R.D. (2020). Firewood certification programs: Key attributes and policy implications. *Energy Policy*, 137, 111160. DOI: https://doi.org/10.1016/J.ENPOL.2019.111160

Wan M., Zhang Y., Ye W. (2018). Consumer Willingness-to-Pay a Price Premium for Eco-Friendly Children's Furniture in Shanghai and Shenzhen, China. *Forest Products Journal*, 68(3): 317-327. DOI: https://doi.org/10.13073/FPJ-D-17-00050

Welford R. (1995). *Environmental strategy and sustainable development: the corporate challenge for the twenty-first century*. Routledge.

Williams R.A., Quiroz C. (2020). *Ordinal Regression Models* (Atkinson P., Delamont S., Cernat A., Sakshaug J.W., Williams R.A. eds.). SAGE Research Methods Foundations.

Wooldridge J.M. (2012). *Introductory Econometrics: A Modern Approach* (South-Western Publications, Ed.; Sixth Edition, Vol. 1).

Zhang X., Dong F. (2020). Why Do Consumers Make Green Purchase Decisions? Insights from a Systematic Review. *International Journal of Environmental Research and Public Health 2020,* 17(18): 6607. DOI: https://doi.org/10.3390/IJERPH17186607