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Attitudes and behaviour of adopters of technological innovations in agricultural tractors: A case study in Italian agricultural system

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Agricultural system has a significant application of technology innovations, such as agricultural tractors, which are the most important and widespread machine in this industry. The behaviour of tractors' users, concerning the introduction and adoption of innovative characteristics, has received low attention. The study here analyses the attitude and opinion of a sample of Italian users of agricultural tractors, concerning some innovations, to outline different profiles of behaviour. The sample is based on 228 farmers, contractors and employees, participating at International Exhibition of Agricultural Machinery. Data are analysed by Multiple Correspondence Analysis and Cluster Analysis. The results show three separate groups of adopters of agricultural tractors by their attitude towards technological innovations in these vital machines: the ‘‘Unwilling’’ users, neither use innovative tractors, nor would like to have tractors equipped with new technological innovations, the ‘‘Willing-Cultural’’ users have traditional machines but would like to have innovative tractors in the future, and the ‘‘Innovative-Owner’’ adopters have and use ground-breaking tractors. In particular, the ‘‘Unwilling’’ category identifies a not negligible market for manufacturers, requesting very essential tractors without any innovative features. The ‘‘Innovative-Owner’’ category, by a market pull model, can support the technological trajectory of the tractors' manufacturers due to their high degree of adoption of new technologies and interest in further new innovations. The attitude by ‘‘Willing-cultural’’ users may originate an additional trajectory of innovation for tractors and a new business opportunity for manufacturers, based on low cost or simplified version of complex innovative features in tractors. These different profiles can be useful to manufactures and innovation developers to better identify target-adopters, to develop innovations that satisfy needs of wide segments of adopters, and speed up technology transfer. Furthermore, the knowledge of these profiles could be useful for policymakers to support fruitful policy in agricultural systems.

Introduction and background

Technological innovation plays a major role in agricultural systems (Ball and Norton, 2002; Coccia, 2005a, 2009a; Ferrari et al., 2013; Pardey et al., 2010; Reece, 1999; Wright, 2012). In particular, agriculture industry has had exceptional advances and application of new technologies, revolutionising the farming (Coccia, 2009a; Sassenrath et al., 2008). Technological innovations are largely applied to agricultural tractors, enabling more efficient production and use of energetic resources, associated to both lower environmental impact and improvement of drivers' working conditions (Day et al., 2009; Korsching, 2001). In fact, the tractor has a central role in farm operations and remains the most important and widespread path-breaking machine in agriculture (Iftikhar and Pedersen, 2011). It pulls, lifts, powers, supports and is often the main status symbol of the agricultural enterprise. Moreover, it is common to find individual farmers faithful to one particular brand (Day et al., 2009). Of course the technology incorporated in a tractor has a considerable influence on production costs and, as a consequence, on retailer price (Von Pentz, 2011). The demand for agricultural machinery strongly depends on farm income, which is influenced by external variables such as agricultural policy, socio-economic environment, people's attitudes, weather and public policies (Vieweg, 2012).

In recent years structural changes in agricultural systems have affected income and investment, increasing the level of uncertainty and reducing the farmers′ propensity to invest in new equipment (Bonati and Gelb, 2005; Vieweg, 2012). In the sixties the high-income countries (Europe, North America, Japan and European Eastern countries) accounted for 43.8% of total global agricultural output, while in 2010 their contribution is reduced to a mere 25.5% (Alston and Pardey, 2014). In these countries, in the last fifty years, the high wages have reduced the total amount of labour employed in farming and the number of people living on farms, with commensurate increases in farm sizes (Alston and Pardey, 2014). In the same time span the stock of tractors almost doubled and the use of modern land- and labour-saving inputs has significantly increased (Alston and Pardey, 2014). Since eighties the agricultural intensification has partially generated the decline of biodiversity and ecological disruptions (Donald et al., 2001). In the European Union countries, since 1992, the Common Agricultural Policy (CAP) has changed from price and production interventions to a policy of direct income aid and rural development (Rabbinge and Van Diepen, 2000; European Union, 2012). CAP has also supported the aims of sustainability, environmental protection and societal goals. The implementation of this strategy has generated fruitful results in agricultural systems (Gil, 2010). In 2010 there were 12.2 million farms across the 28 countries of the European Union (EU-28), working 174.1 million hectares (ha) of land (the Utilized Agricultural Area), representing 40% of the total land area of the EU-28. The average size of each agricultural holding (farm) was 14.2 ha (Eurostat, 2013). There were a large number (6 million or half of all holdings) of very small farms (less than 2 ha in size) that farmed a small proportion (2.5%) of the total land area used for farming, while a small number (2.7% of all holdings) of very large farms (over 100 ha) farmed almost half (50.2%) of the farmland in the EU-28 area (Eurostat, 2013). This difference affects the economic size of holdings: 5.5 million holdings (44.6%) had in 2010 a standard output below € 2000 and were responsible for only 1.4% of total agricultural economic output, while 1.9% of holdings had a standard output in excess of € 250,000 accounted for 47.8% of all agricultural economic output (Eurostat, 2013). If we compare the United States, in 2012, the number of farms was estimated at 2.17 million and the total land in farms at 370 million ha. The average farm size in US was 170 ha with great differences among States: Rhode Island had the smallest farm′s average size, roughly 23 ha, while Montana had the largest one: 1131 ha (USDA, 2013). In 2012 USA farms with an income lower or equal to $ 10,000 were 54% and farmed 10.8% of the total land, while farms with income higher than $ 250,000 absorbed about 50% of the land (USDA, 2013).

In 2010, one out of four of the EU-28′s holdings was in Italy (13.2%), on average 7.9 ha in size (Eurostat, 2013; Inea, 2012). In 1990 the average Italian farm′s Utilized Agricultural Area (UAA) was 5.5 ha. The number of Italian farmers decreased from 2.6 million in 1990 to 1.62 million in 2010. During the same period, the UAA in Italy declined from nearly 15 million to 12.9 million ha. Although there is an increase in average size of the business, Italian agriculture continues to be characterized by a very large number of very small companies that affects the economic performance of the sector. Small farms, with less than 2 ha of UAA, represent 50.6% of the total UAA, while holdings with a standard value production of less than € 8000 represent 62% of the total Italian farms, accounting for only 5.3% of the total standard production of domestic agriculture. Farms with such modest economic weight have low investments on expensive machinery and contractors assume an important role. The latter can provide a large number of services to the farming industry, typically dealing with land, fields, or crops, including for example, fertilization, chemical applications, harvesting crops and manure spreading. In Italy the number of these operations is estimated to be more than 10,000.

In addition, Italy has about 310,000 (19% of the total) holdings with a size and income that can be considered real ″ business″. These companies account for almost 90% of the Italian standard production, whose total value amounts to approximately € 49.5 billion (Inea, 2012).

Italian agricultural system is based on farms that have about 1.75 million tractors in 2008 (Unacoma, 2008), such that Italy is in 3rd place in tractor fleet after USA and Japan (World Resources Institute, 2012). This means that Italian farms tend to have a tractor density of approximately 138 units per 1000 ha; it is a very high ratio if compared with Germany (85.8), France (64.5) and US (26.8) (World Resources Institute, 2012). As well as, Italy is a world leader in tractor production (Unacoma, 2008). In particular, Italian agricultural machinery manufacturing industry is made up of large globally active groups and small and specialized companies.

Italian and European farmers have to take into account this entire context when they invest in new technology (cf. Coccia, 2005c, 2007). It is unlikely for farmers to adopt innovations as soon as they appear on the market; investment lags are frequently explained by their economic attribute, and more specifically, by the uncertainty about the future value of investments and sunk costs (Marra et al., 2003; Tozer, 2009). Adoption of a new technological machine is often a difficult decision, though it shows obvious economic advantages (cf. Rogers, 1995).

The analysis of adopters of technological innovation, the recipient absorbing technology, is important to evaluate their behavior in using new technologies and to support appropriate innovative strategies of firms in turbulent and fast-changing markets (Bunduchi et al., 2011; Coccia, 2004a, 2005b, 2008, 2010a; Macrı` et al., 2001; Yu and Tao, 2009). Economic and managerial research can facilitate companies to develop new products, to better and quickly satisfy users′ needs, and therefore customer requirements in terms of innovative products that they subsequently purchase (Calabrese et al., 2005; Dunk, 2004; Jeffrey and Franco, 1996).

In brief, current R&D investments in advanced countries, associated to other factors, support technological change to spur productivity of industries and economic growth (see Coccia, 2009b, 2010a, 2010b, 2012, 2013, 2014a, 2014b). Different theories have been developed to describe and assess the adoption and diffusion of technology (Burkman, 1987; Carr, 2001; Coccia, 2004a, 2004b, 2005a, 2009a; Farquhar and Surry, 1994; Macrı` et al., 2001; Marra et al., 2003; Rogers,1995; Stockdill and Morehouse, 1992), the mechanisms and main issues concerning technological absorption of adopters and their geo-economic space (Coccia, 2005b, 2008, 2010a, 2010b, 2010c; Cohen and Levinthal, 1990; Kingsley et al., 1996; Macrı` et al., 2001; Young, 2009, p. 1900; Yu and Tao, 2009), and the role of users in the process of technological development (Bunduchi et al., 2011; Oudshoorn and Pinch, 2005). Furthermore, the adoption of technological innovation can be considered a phase of the technology transfer (Coccia, 2005b, 2008, 2010a): a subject acquires technical knowledge and/or new technology from the source (Cutler, 1989). In general, the users (or adopters) link the technological knowledge to the ease of acquisition, comprehension and application of the technology (Coccia, 2004a, 2005a, 2005b, 2008, 2010a; Coccia and Rolfo, 2002).

Users of agricultural tractors have had for many years a passive role without contributing to the R&D process of leading firms (cf. Coccia, 2014c; Douthwaite et al., 2001). Over the past decade the importance of adopters has emerged, in line with a market-pull approach to support fruitful technological trajectories in several industries such as in agriculture (Glenna et al., 2011). Although consumers have received considerable attention in R&D, there is a dearth of economic studies on the impact of farmer perceptions in the agricultural sector (Gasparin et al., 2008); in fact, fragmented information are available on attitude of adopters towards technological innovations in agricultural tractors (Cavallo et al., 2014a 2014b; Kruize et al., 2013; Reichardt and Jurgens, 2009), and some manufacturers of tractors make the effort to collect information and understand their customers, but these information remain mainly for internal use (Ferrari et al., 2013).

Adesina and Baidu-Forson (1995) support the hypothesis that farmers′ perceptions of technological characteristics significantly affect their decisions. In addition, people who ultimately use technologies can influence their development and application (Glenna et al., 2011). Thus it is important, more and more in a turbulent market, to gain information of technology′s adopters (characteristics and demographics) to understand their priorities, attitudes and beliefs, what they know about new technology and how users get information to determine their purchase behaviour (Nielsen, 1993).

Current studies describe different innovations concerning tractors and their success among users (Day et al., 2009; Duarte and Sarkar, 2009; Kruize et al., 2013; Renius, 1994, 2009; Renius and Resch, 2005). In Italy, although statistics report detailed data about number of tractors and adopters, there is a dearth of information about technological development in the market of tractors as well as about the behaviour and attitude of users towards technological innovations of tractors. This paper endeavours to analyze the attitudes, opinions and behaviours of users towards new technologies applied on agricultural tractors. The results, concerning a case study in Italy, can shed light on users′ behaviour, needs and attitudes towards new technology in tractors of different agricultural areas that could be useful to support manufacturers and innovation developers in their strategic decisions for fruitful technological trajectories.

Methodology and research design.

The study was conducted by interviewing visitors with a questionnaire at the 37th edition of the International Exhibition of Agricultural Machinery (EIMA) held in Bologna (Italy) in November 2010. The survey involved more than 300 Italian individuals, 18-year-old or more, randomly selected during the exhibition opening hours among the visitors of the EIMA agricultural tractor pavilions.

As population of agricultural industry has a sparse distribution across agricultural areas, the agricultural exhibitions are a main occasion of confluence and a suitable place to collect information (Cavallo et al., 2014c; Gorucu et al., 2014; Kuijt-Evers et al., 2003; Reichardt and Jurgens, 2009; Tillapaugh et al., 2010). In addition, as the questionnaires included technical terms and other information that needed explanations, the face-to-face interview was considered the best technique to collect reliable data. Other methodologies have several weaknesses: in general, mail questionnaires to farmers have low reply (Jenkins et al., 2012; Mariger et al., 2009), while telephone survey response rates are generally decreasing in recent years (Carey et al., 2013).

The questionnaires, designed using web-based survey software (www.surveymonkey.com), were administered by a computerassisted personal interview. This innovative approach is judged appropriate considering the focus on innovations, and it has clear advantages over traditional paper-and-pencil questionnaire (Greenlaw and Brown-Welty, 2009). Data were collected on a group of tablet computers (i-Pad).

The questionnaire is divided into several sections containing factual questions (objective content), attitudinal/opinion questions (subjective content), and demographic information (see Table 1). Furthermore, participants to the survey were asked to report data on tractor(s) they currently use, their sources of information on technology innovations applied to tractors, their knowledge and perceived usefulness of technological innovations, the aspects considered important in agricultural tractor usage, and their propensity towards technology advancements applied to tractors.

Respondents′ opinions were measured by a four-point Likert balanced and forced scale of agreement (1 = not at all, 2 = a little, 3 = somewhat and 4 = very much) (Likert, 1932). A set of demographic questions conclude the questionnaire (see Table 1).

The tractor′s technological features investigated during the survey are listed and briefly described. The abbreviations in [square bracket] are used later in the text, graphs and tables.

- [CVT] Continuously Variable Transmission. CVT transmissions can change steplessly through an infinite number of effective gear ratios between minimum and maximum speeds. CVTs allow to select the most appropriate engine′s revolutions per minute (rpm) speed for the vehicle speeds. CVTs enhance tractor productivity, energy efficiency, environment protection and comfort of drivers (Renius and Resch, 2005). The Fendt ″Vario″ is the most known CVT transmission.
- [GPS] Assisted Guidance System. The system drives automatically the tractor along a predetermined trajectory (Bell, 2000), relieving the operator from many tasks involved in driving a vehicle. It uses a combination of GPS receiver, tractors′ on-board sensors, computer to process the information, and actuators on the tractor′s steering system (Yao et al., 2005).
- [NCfuel] Non-Conventional fuels. The most relevant alternative fuel for Diesel engine fitted on agricultural tractors is the biodiesel fuel (Bindraban et al., 2009; Fredriksson et al., 2006; Hansen et al., 2005). It can be used directly or as blends with Diesel fuel (Demirbas, 2009) and it does not require modifications in existing Diesel engines (Patterson et al., 2006). The performance, compared to conventional mineral Diesel, is not significantly lower (Bozbas, 2008; Tomic et al., 2013).
- [POWER] Overpower/Power-Boost. It is an electronic setting of the engine that makes possible to deliver additional power to the power take-off (PTO) or the driveline in specific working conditions, improving performances of tractors.
- [RD] Remote diagnostics system. The system enables the tractor to communicate to a remote recipient (a computer) specific conditions of components or systems, for example when maintenance is required (You et al., 2005)
- [ISO] ISOBUS/CAN-BUS. It consists in the electronic communication among sensors, actuators, control elements, and information-storage and displays units embedded in tractors, and other self-propelled agricultural machines. It is based on the ISO 11783 Standard for electronics communications protocol for agricultural and forestry equipment (Cox, 2002;
- International Organization for Standardization, 2007). The system can be used to coordinate machine components and to share information (Stone et al., 1999; Renius, 2009).
- [Speed] speed greater than 40 kph (25 mph). Manufacturers offer tractors with a maximum speed higher than 40 kph to increase transport performance. The solution requires truck standard engineered solutions on suspension on front and rear axles, on steering and braking systems and on wheels and tyres (Clay and Hemingway, 2001; Day et al., 2009). The most commercially successful tractor in this category is the JCB ″Fastrac″.

- [HPBS] Hydraulic or Pneumatic Braking Systems. It consists in compressed air or hydraulic brakes components integrated in the tractor or available as retrofitting components.
- [FLEET] fleet management. Agriculture application of fleet management systems, a tool commonly adopted in transport and construction business (Sorensen and Bochtis, 2010), permits to have better timing of land work and co-ordination of available equipment. The benefits of such a system are the less traffic and number of trips in field and on road, the more adequate coordination of transport vehicles, the site-specific accumulation of goods and machinery use, and the decrease in energy and labour costs (Auernhammer, 2001).
- [ELECT] Electric actuators. Electrical driven actuators, mainly engines, can replace mechanical or hydraulic driven ones. This solution optimizes the power flows across agricultural machines, reduces mechanical complexity, increases flexibility in arrangement of components, enhances productivity and operator comfort, as well as reduces costs (Buning, 2010). Some examples of application of this technology are the sprayers from the company Amazone and the fertilizer spreaders and seed drills manufactured by Rauch.

Table 1
Questionnaire.

A Objective content — Active variables

A.1 Farms characteristics

Dimension		Number of agricultural tractors (TR)		Geographical origin	
<5 ha	*Less than 5 hectares*	1–3 TR	*Between 1 and 3*	Central	*Central Italy*
5–20 ha	*Between 5 and 20 hectares*	4–6 TR	*Between 4 and 6*	N_E	*North-East Italy*
>20 ha	*More than 20 hectares*	7–9 TR	*Between 7 and 9*	N_W	*North-West Italy*
		>9 TR	*More than 9*	South-Islands	*South Italy and Islands*

A.2 Tractors characteristics — *1A.3 Work characteristics of survey respondents*

State		Activity		Years of work		Type of farming	
Out_TR	*Outdated (>30 years old)*	Farmer	*Farmer*	W < 3 y	*less than 3 years*	Arable	*Arable crops*
Old_TR	*Old (10–30 years old)*	FarmW	*Farm worker*	W3–10 y	*Between 3 and 10 years*	Livestock	*Livestock*
Mod_TR	*Modern (<10 years old)*	Contr	*Contractor*	W>10 y	*More than 10 years*	Vine_Orch	*Vineyard/orchard*
Mod_Old_TR	*Modern and old*					Forestry	*Forestry*
Mod_Out_TR	*Modern and outdate*					Hort_Flor	*Horti/floriculture*
						Other	*Other*

A.4 Characteristics of survey respondents

Gender		Age		Study title	
F	*Female*	18–25	*Between 18 and 25 years old*	Elementary	*Elementary*
M	*Male*	26–35	*Between 26 and 35 years old*	JHS	*Junior high school*
		36–45	*Between 36 and 45 years old*	HS	*High school*
		46–55	*Between 46 and 55 years old*	University	*University*
		>55	*More than 55 years old*		

B Subjective/objective content — Active variables

B.1 Ownership/desire of technological innovations already available on the market (10 innovations); X= technological innovation/characteristic

OWN_[X]	Owns/works with a tractor equipped with [X]
Next_[X]	Wishes to own/work with a tractor equipped with [X]
NO_[X]	Does not own/work and does not desire to own/work with a tractor equipped with [X]

C Subjective content — Supplementary variables

C.1 Knowledge and perceived utility of technological innovations already available on the market; X= technological innovation/characteristic

Know_[X]+	High perceived usefulness of a specific innovation know [X]
Know_[X]−	Low perceived usefulness of a specific innovation know [X]
Know_[X]?	Lack of knowledge related on a specific innovation [X]

C.2 Validity/utility of the information channels

INFO[X]+	The use of a specific [X] information channel is perceived to be highly useful	[press]	Agricultural and technological dedicated press
		[internet]	Internet
INFO[X]−	The use of a specific [X] information channel is perceived to be not useful	[sellers]	Sales networks
		[fair]	Fair and events
INFO[X]?	Not use of a specific [X] information channel	[colleague]	Colleagues
		[e&rINST]	Education and/or research institutes and centres
		[prof_ass]	Professional associations

The statistical analysis was conducted exclusively on individuals who directly affect the tractor market sector, as they are the people who purchase, or actually make a direct use of tractors. Multiple Correspondence Analysis (MCA) using R software by FactoMineR (Escofier and Pages, 2005) and CA packages (Greenacre, 2007) was applied. MCA is a technique used to detect and to represent underlying structures in a dataset. The variables listed in A and B of Table 1 are considered as active variables – the variables directly used for computing the factorial plane – while C variables are supplementary information. The percentage of explained variance of the first two factors is re-evaluated using the Benzecri (1973) method. A further Cluster Analysis (CLA) using Ward hierarchical method was conducted to confirm MCA results and to group participants by response affinity. The CLA, unlike the MCA, gives a numerical evaluation of the groups.

In particular, the study here, by these statistical analyses, endeavours to detect attitudes of different users, called *personas* (Norman, 1988; Cooper, 1999), of agricultural tractors with or without some innovative characteristic or specific technology. A persona is an artificial person, an archetypal user that represents the needs of larger groups of users, in terms of their goals and personal characteristics. They identify the motivations, expectations and goals of adopters and their behaviour. Personas are applied for a long time in user-centred design methods by designers to understand the people that use specific products (Carroll, 1995; Cooper, 1999).

Results and discussion

The case study of Italy shows interesting results. Ninety-five percent of the respondents to the survey was male. Fifty-seven percent of individuals interviewed was farmers, 9% was agricultural workers not running their own business, 8% was contractors, 8% was students, 3% was dealers and people working in the agricultural machinery service and maintenance business. Fifteen percent of the sample was represented by individuals whose primary work activity was not related to the agricultural sector. Students, people working in service sector, and people whose primary work activity was not related to agricultural sector have been removed from the sample. Hence, the statistical analysis was conducted on 228 questionnaires, accounting for 75% of the total collected data, taking into account farmers, contractors and agricultural workers. Twenty-one percent of the sample belonged to the age 18–25 years old. Another 12% of the sample was in the group 26–35 years old, and an additional 21% was in the category 36–45 years old. The group aged 46–55 was represented by 25% of the individuals, while 9% was in the 56–65-year-old category and 3% was 75-year-old or older. One fifth of the sample was young people, nearly ″digital native″ and more familiar with technologies.

Twenty percent of the sample was from Northwest of Italy, 35% from Northeast, 18% from the Central Italy, 19% from the South and 8% from Islands (Sicily and Sardinia). More than half of the sample was from North Italy, the area with the more intensive and profitable farms. This likely can be due to the place where the exhibition takes place, Bologna, that is in the North of Italy, so, it is easier to be reached for people from North and Central Italy than visitors from South of Italy and even more from Islands.

Fifty-three percent of the individuals interviewed used tractors to work on arable land, 36% in vineyards and orchards, 18% in livestock farms, 11% in horticulture and floriculture and 6% in forestry. More than an answer was admitted, so the total exceeded 100%. Six percent of the respondents used the tractors on farms smaller than 5 ha, 40% on farms with size between 5 and 20 ha, and 54% in farms larger than 20 ha. The size of the farms owned or where respondents worked was larger than Italian national average (7.9 ha). Previous study on the same sample showed that the adoption of technological innovations in agricultural tractors is positively associated to larger firms (Cavallo et al., 2014a).

The most profitable farms are in the northern regions of Italy, mainly due to a greater presence in these areas of intensive farming where predominate livestock dairy farms, large industrial pig and poultry businesses, and arable farms with large size (26.8 ha) above the Italian average (Inea, 2012). In this area, there are several operations and the demand for the most advanced agricultural machinery is the highest. On the opposite, horticulture farms stand out for economic performance but costs are mainly due to intense use of structures and labour, and demand for traditional agricultural machinery (tractors) is limited.

Thirty-five percent of the sample used in their own farm or worked with (being a farm worker or a contractor), between 1 and 3 tractors, 38% used between 4 and 6 tractors, 13% used between 7 and 9 tractors, and 14% used more than 9 tractors. These figures are far-off from that of the statistics that report approximately 1.5 tractors for any of the Italian agricultural holding (Unacoma, 2008; Inea, 2012).

The tractor innovations investigated in this survey are analysed and firstly ordered according to the percentages of respondents who actually have them (OWN), who wish these innovations (Next), and who do not have and neither want to have innovations (NO). The results are visually presented in the ternary diagram in Fig. 1.

In the diagram, the distance of each label from any of the side of the equilateral triangle is proportional to the percentage of the item indicated on the side. For example, HPBS and CVT are the most available technologies among the sample (in the graph they are at the farthest location from the OWN side), they are also the most desired technology (in the graph they are at the farthest position from the Next side), and that people not interested in innovation are less unfavourable (in the graph they are at nearest location from the NO side). Similarly, Electric actuators, fleet management system and ISOBUS/CAN-BUS technologies are currently very little available and desirable in the future, and the most useless. It is interesting to see that the alternative fuels (biodiesel), currently almost unavailable on the Italian fuel market, turn to be highly attractive for individuals more receptive to innovations, while people not interested in innovations are not completely unfavourable to its adoption. In the MCA the variables with objective content are directly used for computing the factorial plane, while variables with only subjective content are added as supplementary information.

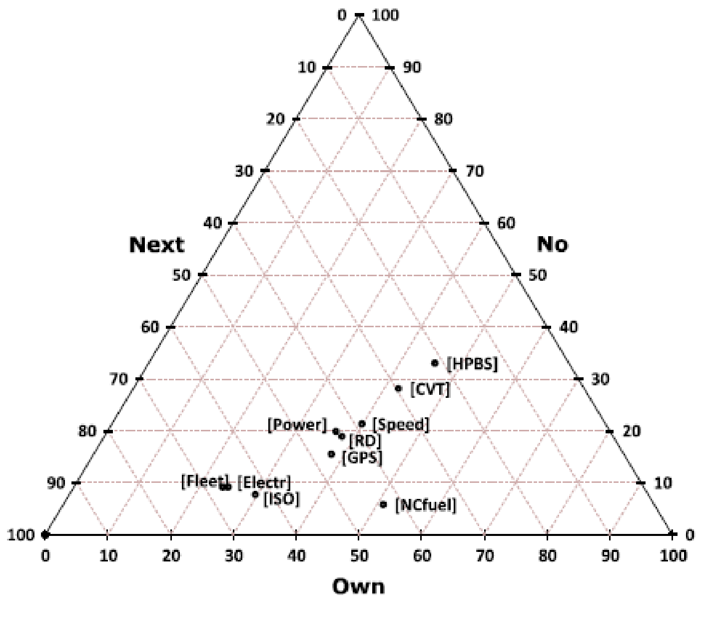

Fig. 1. Distribution of technological innovations according to the percentages of respondents. *Note:* The three sides of the triangle represent for each innovation [X] the percentage of those who have it (OWN), those who wish to have it (Next), and those who do not have it and do not want to have it (NO). [CVT] Continuously Variable Transmission; [GPS] Assisted Guidance System; [Ncfuel] alternative fuels; [POWER] Overpower/Power-Boost; [RD] Remote diagnostics system; [ISO] ISOBUS/CAN-BUS; [Speed] speed greater than 40 km/h; [HPBS] Hydraulic Pneumatic Braking Systems; [FLEET] Fleet Management; and [ELECT] Electric actuators.

Table 1 summarizes the variables, while Fig. 2 shows their graphical presentation in the MCA. A significant contribution to the interpretation of the MCA output is given by users′ ownership/desire of technological innovations. This variable has both objective and subjective content. The objective content is related to the technological innovations that participants had or do not had available (variables labelled OWN_[X] and NO_[X], where X indicates the technology, indicated by the acronym in statistical analyses performed, cf. the list in the ″Method″ section), while the subjective content refers to those innovations that some adopters wished their tractors were equipped with, or, in other words, the technological innovation they ″desired to have″ (see variables labelled Next_[X]).

The presence and the willingness of technological innovation spread across the factorial plan (light and dark grey, and white boxes) considering the horizontal (first factor) and vertical (second factor) dimensions. Individuals that already had the investigated technological features implemented on their tractors are on the right-hand side of the graph (dark grey boxes). A distinct polarization appears between participants positioned on the left-hand side of the chart: those who did not own or worked with tractors equipped with technological innovations and were not interested in having it (white boxes) are in the bottom area, while adopters who did not have the technological features implemented on their tractors, but they desired to have them, are in the top area (light grey boxes).

In short, the first dimension (horizontal) of the factorial plane has an objective explanation, opposing actual presence of technological features on agricultural tractors (on the right-hand side) to the lack of innovation (left-hand side).

Individuals owning or working in smaller business, both in terms of size and tractors′ fleet, are positioned on the left-hand side of the graph; the same area is associated to respondents that did not use of tractors that implement the technological features studied. Individuals working in larger farms or dealing with fleets with higher number of tractors can be found moving to the right-hand side of the factorial plane (the solid arrow in Fig. 2).

The technical state of the tractors (the circular shapes in Fig. 2) follows the same path from left-hand to right-hand area

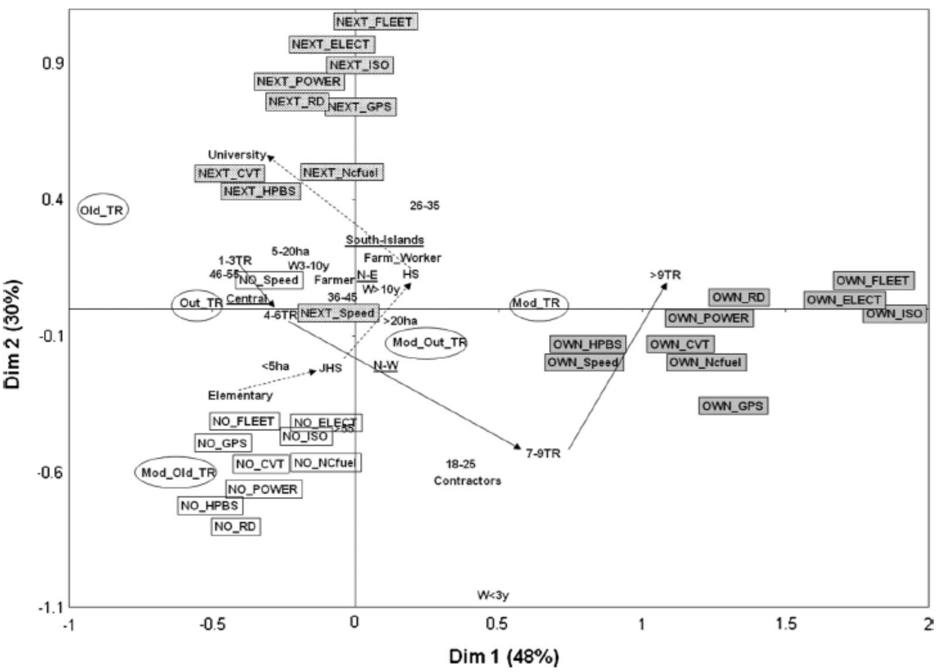

Fig. 2. Projection of active variables in the Multiple Correspondence Analysis (MCA). *Note:* OWN_[*X*]: owns/works with a tractor equipped with feature *X*; Next_[*X*]: wishes to own/work with a tractor equipped with feature *X*; NO_[*X*]: does not own/work and does not desire to own/work with a tractor equipped with feature *X*. Where *X* indicates the technology/technological characteristic: [CVT] Continuously Variable Transmission; [GPS] Assisted Guidance System; [Ncfuel] Not conventional fuels; [POWER] Overpower/Power-Boost; [RD] Remote diagnostics system; [ISO] ISOBUS/CAN-BUS; [Speed] speed higher than 40 km/h; [HPBS] Hydraulic Pneumatic Braking System; [FLEET] Fleet management; and [ELECT] Electric actuators. See Table 1 for abbreviations.

of the factorial plane, according to a classification that goes from prevalent use of old tractors (far left-hand side of the graph) to outdated tractors and modern tractors (on the right-hand side of the chart). This confirms the correctness of the MCA method. In Italy a large number of the tractors in use, 40% in accordance to the statistics from INAIL (the Italian Workers′ Compensation Authority) is more than 30 years old, with a low technological contents, especially concerning safety issues (Fargnoli et al., 2012).

As far as geographical origin of individuals is concerned (item underlined in Fig. 2), the respondents from Central Italy are in the left-hand side area of the graph, the less technological area, while the individuals from other Italian regions show higher interest in technological innovation. Statistics on income from Italian agriculture (Inea, 2012) reports that farms in the centre of the country have an average Gross Saleable Production considerably lower than northern regions, and as a consequence, less propensity to invest in more expensive machinery.

In Fig. 2, considering the professional role, moving from the left-hand side, farmers, agricultural farm workers and finally contractors can be found; considering the horizontal dimension (the actual presence of technological features on tractors), individuals that run his own farm seem to have less opportunity to use modern tractors than farm workers and contractors. This is because contractors adopt more advanced equipments to remain competitive. The second dimension (vertical) is explained mainly by subjective opinions related to the desire of (top area) or lack of interest in or opposition to (bottom area) technological innovations. Dash arrow shows that increasing the education of respondents, the interest in innovations increases. In particular, individuals with university degree do not have available innovative features on their tractor but they wish to have in the future. Individuals gathered by age have a similar vertical arrangement, mostly driven by the desire of having vital technological features applied on their tractors. Groups of age between 25 and 55 years old, the mature workers, are also generally interested in having technological innovations implemented on their tractors. On the opposite, people aged 55 and older, are not interested in innovative features on their tractors. Some technological features, such as fleet management systems, electronic actuators and ISOBUS/CAN-BUS systems, generally are recognized as the most attractive innovations by respondents that did not have them on their tractor in use. They are spotted on the top left-hand side of Fig. 2 (the area targeting individuals who would like to have technological innovations), slightly higher compared to other technological features. Furthermore, these technological features are those that the individuals less interested in tractor technological innovations are less opposed to their utilization (being in the highest position among all the features in the white boxes, cf. bottom left-hand side in Fig. 2). CLA (Cluster Analysis) groups the answers according to their affinity. The CLA gives three clusters, representing three quite separate groups (Fig. 3). The three groups correspond to the three categories already identified in the MCA factorial plane and outlining the three different profiles of users previously identified:

- Cluster 1 (21% of the sample), the ″NO″ group: respondents who neither use, nor would like to have tractors equipped with technological features.
- Cluster 2 (26% of the sample), the ″Next″ group: individuals who do not have tractors with innovative features and would like to have them in the future.
- Cluster 3 (53% of the sample), the ″OWN″ group: subjects who already have and use the technological features on their tractors.

Two additional supplementary variables have been included in a further analysis performed with the MCA: the resources of adopters to be informed about the innovative technologies on tractors and the level of knowledge and appreciation of the technological innovations on tractors. The sources of information about innovative technology of tractors are displayed in Fig. 4.

The results show that the perception of the benefits of different media follows a bottom-up trend graphically represented by arrows: from low benefit, marked as INFO[X]-, in the middle area of the factorial plane, to the high usefulness, INFO[X]+, on the top area of the chart (Fig. 4). Responses linked to the non-use, INFO[X]?, of any of the source proposed during the survey are gather on the bottom area of the graph, corresponding to the region of the factorial plane with individuals having low educational level. The trend matches the qualification development that is usually accompanied by a greater appreciation for technological features.

The arrows, in Fig. 4, following a bottom-left to top-right direction, show an increase of interest and benefit gained by the use of the different media as the size of the farm or the number of tractors raise. Individuals with higher educational level assume to have more valuable information from education and research institutions, while less qualified individuals consider professional associations a better source of information about new technologies. The evolution of the perceived value of the information obtained from the sale network has its specific pattern: the consideration for this source of information increases as the qualification decreases and the availability of tractors with higher technological content raises. The results of the MCA on the level of knowledge and appreciation of technological innovations on agricultural tractors are in Fig. 5. Here the factorial plane can be divided into 3 regions: the ″Unknown zone″, Know_[X]?, in the bottom left-hand region, where there are the individuals that do not have any knowledge about the technological features investigated, the ″Uselessness zone″, Know_[X]_, in the central region, and the ″Usefulness zone″, Know_[X]+, on the top right-hand region. The direction from central region of the graph to the top right-hand shows that the perception of usefulness of innovations increases.

In Fig. 5, the horizontal dimension represents the size of the business and/or the number of tractors respondents deal with, and the vertical dimension corresponds to their qualification in term of school degree. Several technological innovations are left-to-right hand and bottom-up oriented (see fine dotted arrows in Fig. 5), meaning that the knowledge and appreciation of technological features increase with the number of tractors and the size of the farms where they are used. Cultural development mainly affects the perception of usefulness of alternative fuels, Electric actuators and remote diagnostics show nearly a vertical bottomup direction (see broken arrows in Fig. 5). Knowledge and appreciation of speeds greater than 40 kph have a specific path: it rises when the cultural level of the respondent decreases and the size of the farms is larger or the number of tractors in use increases (see solid arrow in Fig. 5). These results are important to define the profile of three groups of tractors′ users, within the Italian agricultural system (the ″NO″, the ″Next″ and the ′ ′OWN″, outlined by the MCA and CLA) that are summarised in three *personas*:

- *Unwilling personas*: lack of use and lack of desire for technological innovation of tractors.
- *Willing-Cultural personas*: technological innovation unavailable in tractor use, but they desire to have innovative; in addition, these personas seek technical information on new technology.
- *Innovative-Owner personas*: technological innovations available in their tractors in use and they display positive attitudes towards future new technology for tractors.

The sketch of the three personas can be expanded considering the issues raised by the investigation. The ″Unwilling″ are generally traditional individuals in their older age, without qualifications, running a small farm in term of size and income, not interested, nor requiring for these reasons, any information or adoption of innovative features on their tractors, and keeping on using their old tractors.

The ″Willing-Cultural″ individuals are generally those in their maturity, with higher qualifications and running business larger than those of the previous group. Nevertheless, the income does not permit, or the size of farm does not justify, at the moment, to invest in tractors with innovative features but, they are eager to have them available in the future on their tractors. They prefer qualified resources to recover information on innovative technologies.

The ″Innovative-Owner″ people are running large operations, e.g., large farms and contractors with large tractors fleets, mostly based on North Italy. They are already using tractors adopting innovative features and they know the benefits that they can get from new technology. These individuals are in their maturity, with high school degree, and get the information about new technology from the internet, the specialized press and from dealers. Dealers are particularly careful with this category of customers because these subjects know and exploit at the best the innovative contents of products; they sell groundbreaking products (e.g., tractors) to make their clients more and more satisfied about the investment.

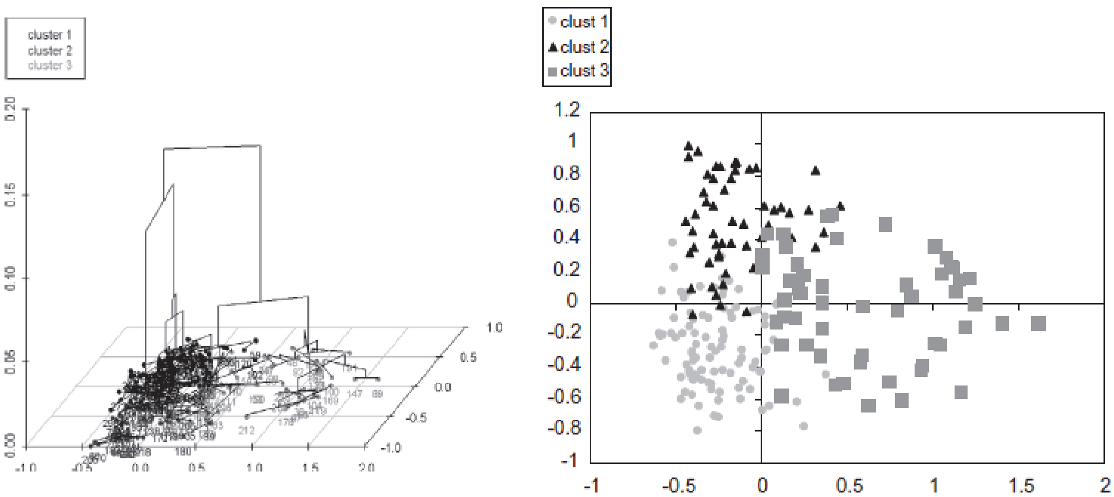

Fig. 3. Respondent grouped with Cluster Analysis. Cluster 1 the "Unwilling"; cluster 2 the "Willing-Cultural"; and cluster 3 the "Innovative-Owner".

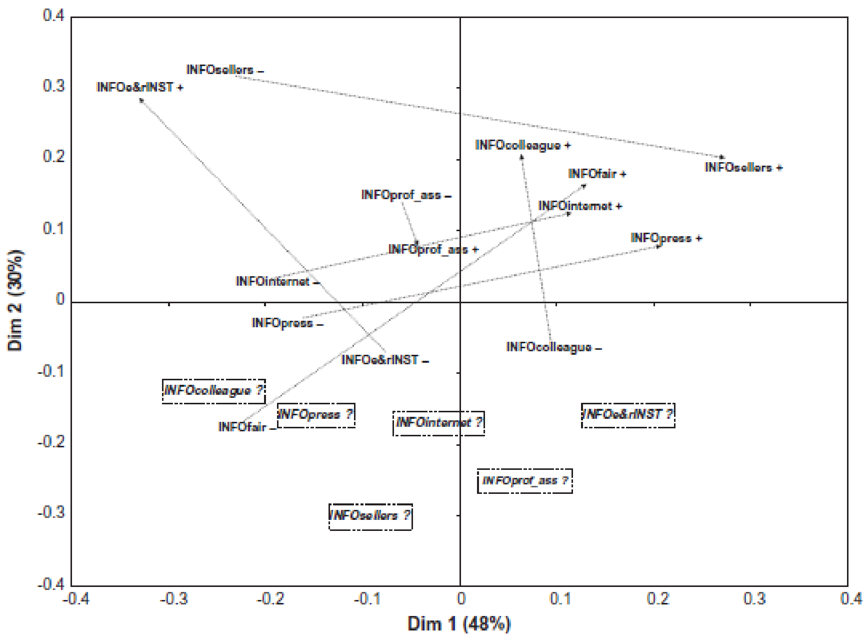

Fig. 4. Multiple Correspondence Analysis (MCA). Projection of the supplementary variables "perceived usefulness of information channels". *Note:* INFO[*X*]+: the use of a specific *X* information channel is perceived to be highly useful; INFO[*X*]–: the use of a specific *X* information channel is perceived to be not useful; INFO[*X*]?: not use of a specific *X* information channel; where *X* indicates: [press] agricultural and technological dedicated press; [internet] internet; [sellers] sales networks; [fair] fair and events; [colleague] colleagues; [e&rINST] education and/or research institutions; and [prof_ass] professional associations.

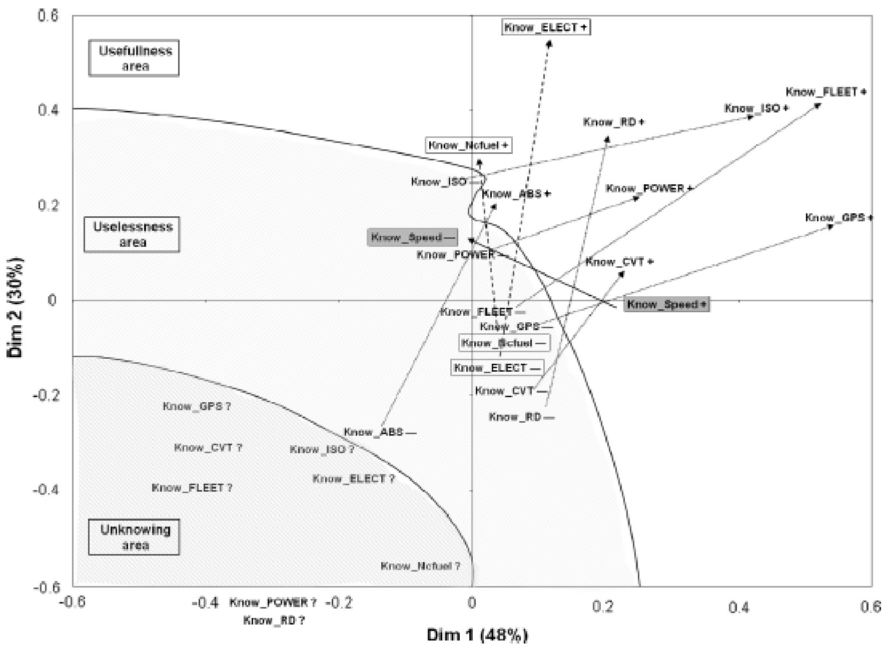

Fig. 5. Multiple Correspondence Analysis. Projection of supplementary variables. *Note:* Know_[*X*]+: high perceived usefulness of a specific innovation know [*X*]; Know_[*X*]–: low perceived usefulness of a specific innovation know [*X*]; Know_[*X*]?: lack of knowledge related on a specific innovation [*X*]; where [*X*] is: [CVT] Continuously Variable Transmission; [GPS] Assisted Guidance System; [Ncfuel] alternative fuels; [POWER] Overpower/Power-Boost; [RD] Remote diagnostics system; [ISO] ISOBUS/CAN-BUS; [Speed] speed greater than 40 km/h; [HPBS] Hydraulic Pneumatic Braking Systems; [FLEET] Fleet management; and [ELECT] Electric actuators. Know_POWER and Know_RD have a *y*-value lower than it appears in the graph.

Discussion and Conclusion

In current agricultural systems, the knowledge about perceptions of tractors′ users towards technological innovations is important for agricultural machinery stakeholders who are looking for new opportunities to expand their business, for research centres which have to address their resources to innovation programmes connected to users′ expectation, and for policymaker responsible for agricultural policy regulations.

The results of this study may support the efficient allocation of human resources and budgets in innovative projects to develop incremental and radical innovations for efficient and safe tractors that fit the expectations of different users. Small tractors′ manufacturers, for example, even if closer to their clients and better placed to know their needs (Vieweg, 2012), do not have the suitable resources to study the market and may find in these results some basic information to better understand users and to develop product innovations and consequently improve their competitiveness in turbulent and competitive settings.

The empirical evidence of this paper shows different behaviours and attitudes towards innovations, making possible to outline the broad profile of three different personas, the ″Unwilling″, the ″Willing-Cultural″ and the ″Innovative-Owner ″. These three different profiles can be useful to manufacturers and innovation developers to identify the behaviour of adopters and to develop innovations that satisfy their needs. In particular, they can encourage the development of fruitful technological trajectories that are requested by users, as well as to differentiate products according to the different propensity of adopters towards the technological features of agricultural tractors.

Twenty-one percent of the individuals interviewed are represented by the ″Unwilling″ persona, not interested in innovative features on tractors. They correspond to a large part of the subjects within Italian agricultural system. They tend to have very small farms with a modest economic weight, and they also play an important role for safeguard the environment and landscape. These users identify a not negligible market for manufacturers, requesting very essential tractors without any special innovative features. Users of tractors, with a more positive attitude towards technological innovations, are those corresponding to the ″Innovative-Owner″ persona represented by those who run large farms or contractors. They are familiar with innovative features and despite economic constraints and uncertainty, they invest in new, advanced and expensive equipment to remain competitive. This category, large farms and contractors, represents a small percentage of businesses, operating in the Italian agricultural system, though they manage the largest portion of land and contribute largely to national agricultural income. Thus they are the recipients of the most innovative and expensive products. The ″Innovative-Owner″ persona supports the innovation trajectory of the tractors′ manufacturers and innovation developers, with a high degree of adoption of new technology. They are those who mainly use the internet and the specialized press to gather information about new technologies; additionally, they also refer to tractors′ dealers to gain knowledge about innovative solutions.

The third persona, the ″Willing-Cultural″, represents one fourth of the respondents. These people operate in small businesses, are culturally developed, and are well documented about benefits of tractors′ innovations. At the moment they do not have available innovative features on the tractors in use, because certain features are available only on high power tractors not suitable for the (small) size of farm, or because the investment required is simply too high; however, they would have innovative tractors. The market analysis of the attitudes towards new technology of this category of customers may spur some interesting technological trajectory for tractors and a new business opportunity for manufacturers in Italian agricultural system. For example, some innovative features, or their simplified or low-cost versions, could be implemented on low or medium power tractors to satisfy some specific persona (adopter).

This investigation, of course, is limited to the agricultural tractors′ end users in Italy. Nevertheless, the results can be broaden to similar situation in different context. For example, the behavior and attitude towards innovations on tractors of the ′′Innovative-Owner′′ adopters in Italian market are probably similar to other large and profitable farms in several European countries. The tools and the principles of the investigation are, of course, applicable to different countries, regions or contexts where different conditions exist to specifically identify profiles of adopters and find out their detailed behaviour and attitude toward innovative features.

However, socio-agricultural systems and, as a consequence, adopters are currently becoming more and more complex in current economies and it might prove difficult to analyse patterns and forecast trends. The conclusions of this study are of course tentative. Hence, there is need for much more detailed research and analysis concerning the attitudes of adopters of innovations in agricultural tractors, in particular in the presence of fast-changing scenarios due to a more and more acceleration of technological change (Coccia, 2005a).

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