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Factors affecting innovation and imitation of ICT in the agrifood sector

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Abstract Diffusion of innovations has gained a lot of attention and concerns different scientific fields. Many studies, which examine the determining factors of technological innovations in the agricultural and agrifood sector, have been conducted using the widely used Technology Accepted Model, for a random sample of farmers or firms engaged in agricultural sector. In the present study, a holistic examination of the determining factors that affect the propensity of firms to innovate or imitate, is conducted. The diffusion of ICT tools of firms which are engaged in the NACE 02/03 as well as in the NACE 10/11 classifications for 49 heterogeneous national markets is examined, using the Bass model. The innovation parameter is positively associated with rural income, female employment, export activity and education of farmers, while the imitation parameter is increased in countries whose societies are characterized by uncertainty avoidance.

Keywords Diffusion of ICT · Agrifood sector · Bass model · Innovation/imitation · Beta-regression

1 Introduction

The adoption of technological innovation by firms in the agricultural and food sector is not new and inevitably has gained a lot of importance, due to the fact that technological updates

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contribute in the increase of production, employment and eventually income (Feder et al. 1985).

Other scholars argue that an increase in growth productivity of the agricultural sector may cause a de—agriculturalization and therefore a decline of the employment in agriculture (Üngör 2013). Many related studies have investigated the adoption of ICT tools in the agrifood sector in specific countries using questionnaires (e.g. Domenech et al. 2014; Batterink et al. 2006; Mondal and Basu 2009). The majority of the papers published (e.g. Aubert et al. 2012; Adrian et al. 2005; Ghadim and Pannell 1999), examine the effect of Rogers' (1995) or Technology Acceptance Model's (TAM) (Davis et al. 1989) dimensions, regarding *compatibility*, *relative advantage*, *perceived usefulness*, *perceived risk* and others dimensions on the adoption of innovation in the agricultural sector.

Several studies examined the adoption as well as the diffusion of innovative applications in the agricultural sector, mostly conducted by rural sociologists. In specific, Gilmore and Rogers (1958), studied the diffusion pattern of hybrid corn in Iowa, comparing results with other countries. In addition, rural sociology made a great impact by identifying the economic and social characteristics which adopter categories possessed in the adoption of hybrid seed corn by Iowa farmers (Ryan and Gross 1943). These traits are among others age, formal education, size of farms, organizational participation, attendance at organization meetings, information access and cosmopolitanism. Based on this theory, scholars have followed and examined the impact that those characteristics have on the decision of farmers to adopt technological innovations or ICT tools (e.g. Aubert et al. 2012). In specific, Batterink et al. (2006) evaluated the factors related to Dutch agrifood industry using survey and resulted in the fact that innovation subsidies have a positive effect on product and process innovation and that firms which are strongly market oriented tend to be successful in product innovation.

The present study contributes to the relevant literature by identifying factors, which affect the propensity of innovation and imitation at an aggregate level using a sample of heterogeneous countries. In line with relevant literature, these factors can be further divided into three main categories: *socioeconomic*, *environmental* and *cultural*. Concerning *socioeconomic variables* income of farmers (Rogers 1995; Domenech et al. 2014), exporting activity (Domenech et al. 2014), female employment (Chandrasekaran and Tellis 2008; Stremersch and Tellis 2004) and participation of countries in international organization (Tellis et al. 2003) tend to have a positive effect on the probability of innovation adoption. On the contrary, regarding the *environmental variables*, probability of adoption is higher in countries where there are low temperatures compared to countries with high temperatures, while lastly concerning the *cultural* dimensions, in countries where societies are risk avenging, innovations are less likely to be successful (Chandrasekaran and Tellis 2008; Tellis et al. 2003).

The rest of the paper is organized as follows: Sect. 2 presents the methodology which includes the description of data and description of the basic diffusion model as well as the model employed to assess the effect of factors on the propensity to innovate and imitate. Section 3 presents the results of the estimated model and conclusions are drawn in Sect. 4.

2 Methodology

2.1 Data

The data were collected from various online databases: data about the time at which firms engaged in agrifood sector have adopted a website (their main activities lie in classification

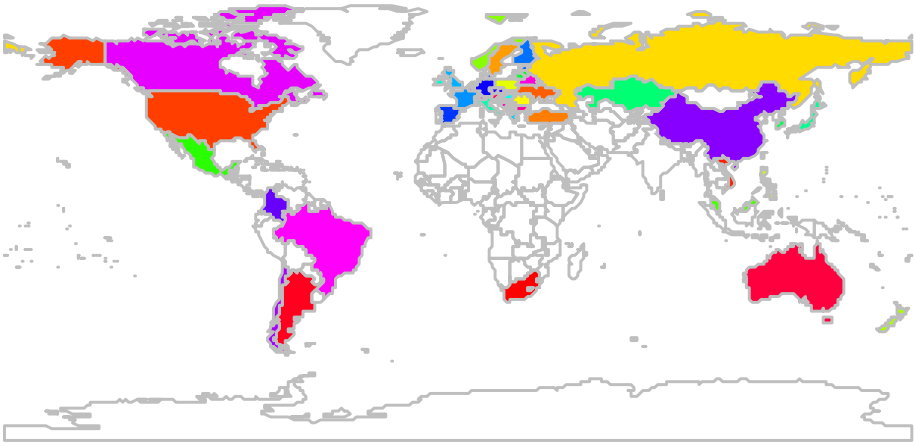

Fig. 1 The countries of the sample

NACE 2, 3, 10 and 11) were collected from the *Orbis* database (Bureau van Dijk), while series for the explanatory variables were collected from the Euromonitor and World Bank online database. For the correct identification of the time at which firms in agrifood sector adopted and launched their website, more than 30,000 companies' websites were collected and analyzed using the Web Archive (https://web.archive.org). The time at which websites were adopted by firms, spans from 1996 to 2016 and concerns 49 countries (Fig. 1).

Overall, 1407 observations were used to examine the propensity that firms innovate or imitate, as well as its determinants. As far as the *socioeconomic* factors are concerned, these are the following: *Rural wealth* is measured in million US$, at constant 2016 prices and fixed 2016 exchange rates and refers to disposable income of household in rural areas per rural population, which is which is the gross income less social security contributions. *Rural education* is measured as the number of graduates in Agriculture ISCED 97 classification 6. This classification includes agriculture, crop and livestock production, agronomy, animal husbandry, horticulture and gardening, forestry and forest product techniques, natural parks, wildlife, fisheries, fishery science and technology, veterinary medicine and veterinary assisting. *Exporting activity* is measured as the ratio of exports (*fob*) to the imports (*cif*) of animal and animal products. These include exports and imports of live animals meat and edible meat offal, fish, crustaceans, mollusks and aquatic invertebrates, dairy products, eggs, honey, and other edible animal products and other products of animal origin and correspond to HS classification 01-05. Exports and imports are measured in million US$ current prices. *Female employment* in agricultural sector includes the percent of female population employed in the agricultural sector and consists of activities in agriculture, hunting, forestry and fishing. *Participation in European Union* is a dummy variable receiving value 1, if a country is EU member and 0 otherwise.

Regarding *environmental* factors, *climate* in each country is measured using average daily air temperature in Celsius.

Lastly, concerning *cultural* dimensions *risk* is measured by Hofstede's (2001) dimension uncertainty avoidance. *Uncertainty Avoidance* is defined as the degree to which members of a society fear anything new and innovative.

Long Term Orientation from Hofstede's (2001) dimensions is used so as to examine how culture of countries affect speed of ICT diffusion in agrifood sector. *Long Term Orientation* is

Table 1 Correlations and descriptive statistics for all explanatory variables

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Exporting activity [1]	1						
Rural education [2]	−0.13	1					
Climate [3]	0.09	0	1				
Rural wealth [4]	0.1	−0.21	−0.26	1			
Female employment [5]	−0.06	0.08	0.22	−0.54	1		
Long-term orientation [6]	−0.34	0.22	−0.28	−0.11	−0.03	1	
Uncertainty avoidance [7]	−0.18	0.05	0.08	−0.48	0.3	0.31	1
Participation in European Union [8]	−0.25	−0.26	−0.26	0.02	−0.22	0.21	0.12
VIF	1.33	1.55	1.37	1.74	1.47	1.37	1.58
Min	0.02	4	−0.01	0.21	0.002	0.13	0.23
Q1	0.54	1017	0.07	2.74	0.017	0.36	0.49
Q2	1.09	3628	0.1	10.86	0.035	0.52	0.68
Q3	2.39	8944	0.14	17.31	0.083	0.68	0.86
Max	51.6	205,900	0.27	36.44	0.72	1	1
Mean	2.93	11,030	0.11	10.91	0.084	0.53	0.67
SD	6.13	25,334	0.06	8.31	0.13	0.21	0.23

defined as the degree to which members of a society are focused on the future. They are willing to delay short-term material or social success or even short-term emotional gratification in order to prepare for the future.

In Table 1, the correlation coefficients between explanatory variables are presented as well as their descriptive statistics. All correlation coefficients are low and the variance inflation index (VIF) does not exceed 2.5, which is a threshold signaling multicollinearity (Greene 2008).

2.2 Research hypotheses

Diffusion of innovative technological products, mainly used by households or individual consumers, has long been examined, for several product categories, countries and time horizons. Hence, formulation of research hypotheses is facilitated using prior knowledge. However, in the framework of the present study, innovation of technological innovations in the content of agricultural sector has not been exhaustively investigated using aggregate data. Formulation and rationale of research hypotheses will result from survey and review papers.

Wealth, regardless of the variable used or the unit of measurement, is a signal of country's prosperity. As stated by Rogers and Shoemaker (1971), "early adopters" are individuals, either consumers or entrepreneurs, very keen on using new technological products which will facilitate their ventures or offer delight. These individuals are often wealthy and educated, that is why they can afford purchasing innovative products, whose price is large when launching into a market (Dee Dickerson and Gentry 1983). In addition, in the context of agricultural sector, wealth is also significantly associated with diffusion speed (Foster and Rosenzweig 2010; Conley and Udry 2010; Duflo et al. 2010), in the sense that large farms or business that are engaged in the agricultural sector, are more likely to invest large amounts of money in new technologies (Adrian et al. 2005). Therefore the following hypothesis could be set:

H_1 Wealth of countries is positively associated with innovation of ICT in agrifood sector.

The extraversion of an economy is defined as the extent to which linkages across countries for imports or exports of new products are established (Tellis et al. 2003). This trade openness conveys flow of technological innovations through consumer's awareness about the availability of new products, resulting in rapid diffusion of new products (Talukdar et al. 2002; Tellis et al. 2003). In addition, Bernard et al. (2007) found a positive correlation between exporting activity of firms and tendency to innovate, due to the fact that international competition is more intense than the regional one, leading to higher efficiency levels (Kafouros et al. 2008).

H_2 Exporting activity of countries is positively associated with innovation of ICT in agrifood sector.

Another determining factor which leads to higher level of technology acceptance is the extent to which human capital is educated and trained (Giunta and Trivieri 2007; Domenech et al. 2014). Rogers and Shoemaker (1971) have described "innovators" as individuals who are wealthy, educated and have a high social status. Therefore, in the context of agrifood sector, innovation of new technologies is facilitated in those countries where farmers are educated. Hence, the following hypothesis could be set:

H_3 Education of farmers is positively associated with innovation of ICT in agrifood sector.

Sex roles in households is according to diffusion relative theory, another factor which determines the propensity of innovation or imitation and consequently the speed of technology adoption (Gatignon et al. 1989). This is ought to the fact that a high percentage of female employed outside the home is related to high income, leading in increased tendency to innovate. However, this positive relationship between female employment and tendency to innovate depends heavily on the type of the technology. In the relative literature, the presence of a high percentage of female employment is associated with increased tendency for innovation concerning products which are time—saving, such as refrigerators, dishwashers and others similar and decreased propensity to innovate for products which are considered as time—consuming and are products used for entertainment (Strober and Weinberg 1977). In the context of the presence study, the technology investigated is the adoption of websites, technology which does not belong to either of the previous two categories of products. Therefore, no research hypothesis shall be set for this variable.

The climate variable is a proxy measure of the degree to which a country is industry oriented (Tellis et al. 2003). In specific, Parker (1997) has used monthly maximum temperature so as to investigate the extent to which climate affects the human mood, work ethic and productivity. The rationale behind this measurement lies in the fact that, in countries where there is cold climate individuals are in need of work activity in comparison with individuals who inhibit in countries where there is warm climate (Tellis et al. 2003). Consequently, in warm countries do not seek innovation, rather they imitate technological advances developed in countries where there is cold climate. The same holds in the context of the agrifood sector. Therefore, the following research hypothesis is assumed:

H_4 Warm climate is negatively associated with innovation of ICT in agrifood sector.

Diffusion of innovations is not explained only by economic and demographic variables, but also by cultural differences among countries of the world. Such cultural dimension, which has been found to play an important role in the decision of individuals for adopting a technology, either in the context of diffusion of innovative products (e.g. Tellis et al. 2003;

Yeniyurt and Townsend 2003) or in the context of agrifood sector (e.g. Suri 2011; Aker 2011) is the degree to which consumers avoid uncertainty (Hofstede 2001). Therefore, in countries where societies are conservative and skeptical towards anything new, innovation is hindered while propensity to imitate is high. Hence, the following research hypothesis is set:

H_5 Uncertainty avoidance is negatively associated with innovation of ICT in agrifood sector.

The last cultural dimension which is associated with the propensity of innovation and imitation is the long term orientation (Hofstede 2001). Long term orientation is defined as the degree to which individuals are willing to quit their expectations in the present and seek success in the future. Individuals in short—term oriented societies are focused on past and present with respect for tradition (Hofstede and Bond 1984), while individuals in long-term oriented societies are characterized by persistence and do not anticipate for quick results (Dwyer et al. 2005). Hence, in countries whose societies are short-term oriented, individuals are more focused on materialistic way of life, while in long-term oriented societies, individuals prefer to save deposits for the future instead of spending in the present, leading to unwillingness to adopt new technologies, for which there is no historical record (Dwyer et al. 2005). Thus, it is expected that individuals are not likely to innovate in societies which are long-term oriented.

H_6 Long-term orientation is negatively associated with innovation of ICT in agrifood sector.

Participation of countries in international unions has been found to be positively associated with faster diffusion of technological innovations (e.g. Tellis et al. 2003). Through unions, capital and personnel mobilization is encourages, economic inequalities are evened and businesses can operate between nations without undergoing market distortions. Sales of innovative products as well as adoptions of new technologies are more likely to prosper in countries which are members of such unions. Mahajan and Muller (1994) concluded that a more unified Europe without borders, results in faster diffusion. Therefore it is expected that propensity to innovate is more enhanced in markets whose countries are members of international unions.

H_7 Participation in European Union is positively associated with innovation of ICT in agrifood sector.

2.3 Statistical Methodology

In order to examine the diffusion of ICT in agrifood sector, the Bass (1969) model is used. Let $x_i(t)$ be the cumulative number of firms in country i which has adopted a website at time t, then the Bass model, can be formulated as follows:

$$\frac{dx_i(t)}{dt} = [p + q \cdot x(t-1)] \cdot [m - x(t-1)]\,. \tag{1}$$

In Eq. 1, p denotes the propensity to innovate, q the propensity to imitate and m the maximum potential of a market (Bass 1969). *Bass model* is widely used due to the fact that it can adjust to monotonically increasing data without incorporating any explanatory variable (Bass et al. 1994) and it can be estimated using maximum likelihood method (Schmittlein and Mahajan 1982), non-linear least squares (Srinivasan and Mason 1984) and ordinary least squares (Bass 1969). In the present study, the method of estimation which is chosen is the non-linear least squares, due to the fact that the parameters p,q and m, as well as their standard

errors can be estimated directly, while estimating Bass model using maximum likelihood method underestimates the standard errors of p,q and m (Schmittlein and Mahajan, 1982).

Bass coefficients, namely p and q for each country and NACE classification category, fall in the range (0, 1). Therefore, the appropriate model to assess the effect of independent variables on the estimated coefficient of innovation ($\hat{p}_i$) and imitation ($\hat{q}_i$) for each country is the *beta* regression (Ferrari and Cribari-Neto 2004). This model is based on a different parameter specification of the *beta* density in terms of the variate mean and precision parameter (Cribari-Neto and Zeileis 2009).

Let $\hat{p}_i : \hat{p}_1, \ldots, \hat{p}_n$ and $\hat{q}_i : \hat{q}_1, \ldots, \hat{q}_n$ be random variables such that $\hat{p}_i, \hat{q}_i \sim B(\mu_i, \varphi)$, where φ is the precision parameter, then the *beta* regression model is defined as:

$$g(\mu_i) = \mathbf{x}_i^T \beta \,. \tag{2}$$

where β is the vector of coefficients to be estimated $\mathbf{x}_i$ the matrix of independent variables' values and $g(\cdot)$ is the link function. Several link functions are tested, in order to choose the best fit. These link functions are the following: *Logit* $g(\mu) = \log[\mu/(1-\mu)]$, *Probit* $g(\mu) = \Phi^{-1}(\mu)$ where $\Phi(\cdot)$ is the standard normal distribution function and *Log–Log* $g(\mu) = -\log\big[-\log(\mu)\big]$. Coefficients of model in Eq. 2 (β), for each specification chosen, are estimated using maximum – likelihood method. The log-likelihood function of *beta* regression is defined as follows:

$$L(\mu_i, \varphi) = \log\left[\frac{\Gamma(\varphi)}{\Gamma(\mu_i\varphi)\cdot\Gamma((1-\mu_i)\varphi)}\right] + (\mu_i\varphi - 1)\log y_i + [(1-\mu_i)\varphi - 1]\log(1-y_i)\,. \tag{3}$$

3 Results

The diffusion of ICT in firms, whose main activities are included in NACE classification 02 and 03, subjects to considerable variations across countries. In specific, in the USA the diffusion of ICT tools for firms in NACE 02 and 03 classifications is faster and more intense compared to other countries, while in Norway and UK the diffusion pattern is identical (Fig. 2). In Fig. 3, the diffusion curves of ICT adoption for firms engaged in NACE 10 and 11 classification activities are presented. The diffusion process in Germany and Italy co—moves and is considerably faster compared to other countries of the sample. On the contrary, Netherlands seems to lead among Greece, Brazil and Argentina, however diffusion of ICT tools in businesses engaged in NACE 10 and 11 sectors lacks speed and is characterized by low market penetration.

Several link function specifications have been tested in order to identify the link function of the *beta* regression model which adjusts data properly. In Table 2, the AIC values for each link function are reported.

Log–Log link is the most appropriate link function for *beta* regression models assuming as dependent variable the estimated coefficients of innovation (p), for the data concerning the NACE 02-03 classification firms. For the *beta* regression model where the dependent variable is the estimated coefficient of imitation (q), *Logit* specification fits better to data. Nevertheless, for the dataset of firms which are engaged in the NACE 10 and 11 classifications, *Logit* link function adjusts better to the explanatory variables than the other specification, namely *Log–Log* and *Probit*.

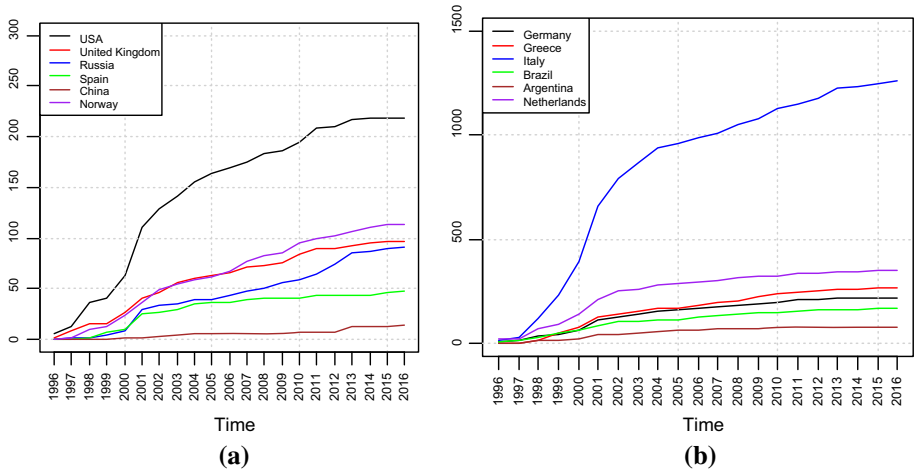

Fig. 2 Cumulative ICT adoptions for selected countries whose main activities lie in a) NACE 02-03 and b) in NACE 10-11

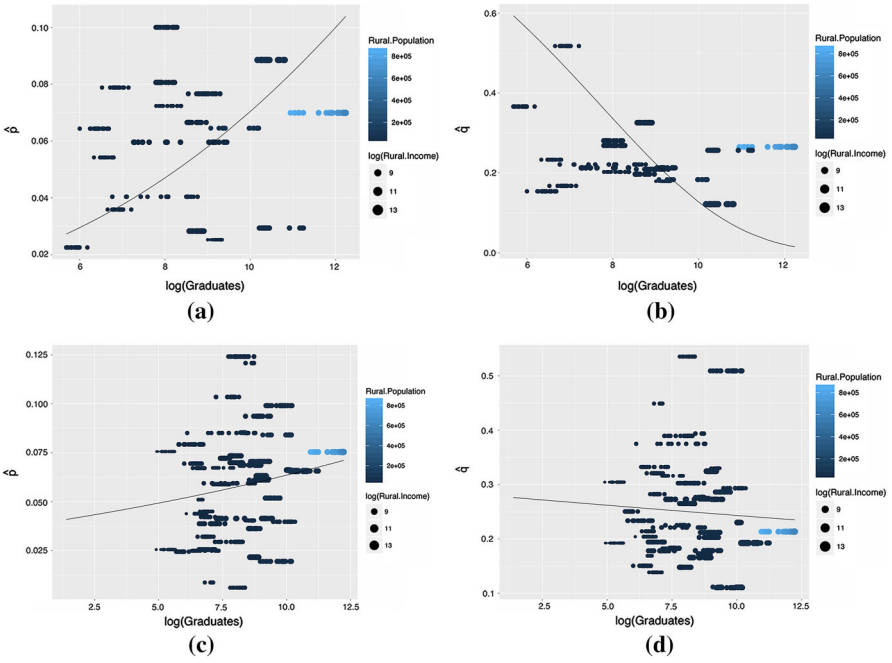

Fig. 3 Coefficient of **a** innovation against number of educated farmers with respect to rural population and rural income for NACE 02-03 classifications, **b** imitation against number of educated farmers with respect to rural population and rural income for NACE 02-03 classifications, **c** innovation against number of educated farmers with respect to rural population and rural income for NACE 10-11 classifications, **d** imitation against number of educated farmers with respect to rural population and rural income for NACE 10-11 classifications

Table 2 AIC values for *beta* regression models

Link function	NACE 02– 03		NACE 10 – 11		All classifications	
	$\hat{p}$	$\hat{q}$	$\hat{p}$	$\hat{q}$	$\hat{p}$	$\hat{q}$
Logit	− 1111.07	**− 1303.09**	**− 2561.64**	**− 471.64**	− 3567.63	**− 1732.46**
Probit	− 1112.62	− 1302.87	− 2561.25	− 471.21	− 3568.23	− 1732.13
Log–Log	**− 1113.89**	− 1302.50	− 2560.87	− 470.81	**− 3568.77**	− 1731.49

Bold indicates that the value of AIC is lower

The results of *beta* regression model for the effect of independent variables on the estimated Bass coefficients p and q for the firms which are engaged in the NACE 02-03 and NACE 10-11 classifications, are presented in Table 3.

Exporting activity is related with coefficient of innovation positively ($b = 0.0036, p < 0.01$) and negatively with coefficient of imitation ($b = -0.013$, $p < 0.01$), for the firms which are engaged in the NACE 02-03 classification. The number of educated farmers is positively associated with innovative trends in the firms whose main activities lie in the NACE 02-03 classifications ($b = 0.074$, $p < 0.01$) and negatively associated with imitation ($b = -0.182$, $p < 0.01$). Innovations tend to prosper in countries where temperature is high ($b = 0.234$, $p < 0.1$), while firms in countries where climate is colder tend to imitate ($b = -1.91$, $p < 0.01$).

Rural income and female employment in agriculture do not seem to have a statistically significant impact on the coefficient of innovation and imitation for the firms in the NACE 02-03 classifications. ICT innovations are hindered in countries high in uncertainty avoidance ($b = -0.138, p < 0.01$) while it seems that it encourages imitating of innovations ($b = 0.148$, $p < 0.01$).

Firms which are located in EU countries are more probable to innovate ($b = 0.169, p < 0.01$) than imitate ($b = -0.422$, $p < 0.01$). Both *beta* regression models, coefficient of innovation (p) and imitation (q) for firms which are engaged in the NACE 02-03 classifications perform very good fit to the data, as the Pseudo R^2 index exceeds the threshold of 20% as suggested by McFadden (1976) (52.1% and 29.15% respectively). In addition, both models are statistically significant (LR = 157.82, $p < 0.01$ and LR = 69.88, $p < 0.01$).

Adoption of ICT tools, in the case of firms in NACE 10-11 classifications, is facilitated with exporting activity ($b = 0.062, p < 0.1$). Education is positively associated with innovating ($b = 0.104$, $p < 0.01$) and negatively associated with imitating ($b = -0.074$, $p < 0.01$). Innovation of ICT tools in agrifood sector is increasing in wealth countries ($b = 0.073, p < 0.05$) as well as in countries where women have an active role in agricultural employment ($b = 1.462$, $p < 0.01$).

The fact that EU countries tend to innovate more than imitate, is verified for ICT tools which are adopted by firms which are engaged in the NACE 10-11 classifications. Cultural dimensions do not affect statistically significant both innovation and imitation parameters.

Concerning the impact of exogenous variables on the coefficients of innovation and imitation for both NACE 02-03 and NACE 10-11 classifications, exporting activity seems to be positively related with innovation ($b = 0.001, p < 0.1$) and negatively associated with propensity to imitate ($b = -0.004, p < 0.1$), however this impact is marginally statistically significant. Agricultural education is a factor which facilitates innovation ($b = 0.0035$, $p < 0.01$) and the same holds for climate ($b = 0.21$, $p < 0.01$). This finding suggests that innovation prospers in warm rather than cold climate countries. Rural wealth of countries affects positively the propensity to innovate ($b = 0.03$, $p < 0.01$) and increased percent of female employment in

Table 3 Estimation results of *beta* regression

	NACE 02-03				NACE 10-11				All classifications			
	Coefficient of innovation (p)		Coefficient of imitation (q)		Coefficient of innovation (p)		Coefficient of imitation (q)		Coefficient of innovation (p)		Coefficient of imitation (q)	
	B	Z	B	Z	B	Z	B	Z	B	Z	B	Z
Exporting activity	0.0036	3.59***	−0.01	−3.28***	0.006	1.77*	−0.002	−0.93$^{n.s.}$	0.001	1.85*	−0.004	−1.95*
Log (Rural Education)	0.07	10.25***	−0.18	−6.11***	0.1	6.09***	−0.07	−4.87***	0.035	7.71***	−0.09	−6.56***
Climate	0.23	1.88*	−1.91	−3.76***	0.25	0.63$^{n.s.}$	1.27	3.5***	0.23	2.26**	0.002	0.01$^{n.s.}$
Log (Rural Wealth)	−0.02	−1.19$^{n.s.}$	0.03	0.48$^{n.s.}$	0.07	2.75**	−0.08	−3.17***	0.03	4.70***	−0.08	−3.99$^{n.s.}$
Female Employment	−0.22	−1.47$^{n.s.}$	0.53	0.81$^{n.s.}$	1.46	6.97***	−1.16	−5.22***	0.48	6.99***	−1.15	−5.42***
Long Term Orientation	−0.65	−9.99***	0.17	0.63$^{n.s.}$	0.21	1.89*	−0.15	−1.56$^{n.s.}$	−0.03	−0.96$^{n.s.}$	−0.31	−3.59***
Uncertainty avoidance	−0.14	−3.9***	0.15	4.04***	−0.10	−0.98$^{n.s}$	0.38	4.01***	−0.04	−1.63$^{n.s}$	0.41	5.17***
Participation in European Union	0.17	9.23***	−0.42	−5.89***	0.16	3.33***	−0.21	−4.96***	0.07	5.71***	−0.25	−6.79***
Log-Likelihood	566.9		245.8		1291		6615		1794		876.2	
Pseudo R^2	52.1%		29.15%		11.32%		16.3%		13.82%		13.77%	
Likelihood Ratio (X^2)	157.82***		69.88***		82.04***		96.87***		122.06***		108.84***	

*$p<0.1$; **$p<0.05$; ***$p<0.01$
$^{n.s}$ not significant

the agriculture enhances tendency to innovate ($b = 0.48, p < 0.01$). Long term orientation and uncertainty avoidance do not have a statistically significant effect on propensity to innovate. On the contrary, long term orientation of societies is negatively associated with coefficient of imitation ($b = -0.31, p < 0.01$), whereas uncertainty avoidance is positively associated with the coefficient of imitation ($b = 0.41, p < 0.01$). Lastly, countries which participate in a unified Europe, tend to be more innovative in the agrifood sector compared to countries which are not members of the European Union ($b = 0.07, p < 0.01$).

Beta regression models, which evaluate the effect of factors on the coefficient of innovation and imitation, do not exhibit good fit to the dataset, as the corresponding Pseudo R^2 indices do not exceed the threshold of 20%. However, both models for all NACE classifications are statistically significant (LR = 122.06, $p < 0.01$ and LR = 108.84, $p < 0.01$).

4 Discussion

Diffusion of ICT in agrifood sector is proved to be in a multilevel way associated with economic and educational national characteristics (Smale et al. 1994). Rogers' (1995) characteristics of innovators and imitators seem to hold in the present study. In specific, firms in agrifood sector tend to innovate when they operate in wealthy countries (H_1 is confirmed) and farmers are educated (Ervin and Ervin 1982; Tey et al. 2017) (H_3 is confirmed).

The propensity of innovation is enhanced in countries with increased female employment in the rural sector. Likewise marketing research theory, female tend to facilitate the adoption of new technologies in order to save time (Dekimpe et al. 2000; Ganesh and Kumar 1996; Putsis et al. 1997).

The extraversion of economies tends to facilitate the propensity of firms in the agrifood sector to innovate (H_2 is confirmed). Firms which are engaged in the agricultural sector need to innovate so as to increase their productivity and supply markets with new products, incorporating low prices and high quality at the same time so as to meet consumers' challenges (Domenech et al. 2014).

However, diffusion and consequently adoption of ICT tools does not depend only on economic conditions but also on cultural characteristics. Avenging risk and in general anything which is new and innovate is a typical characteristic of societies which tend to imitate rather than innovate (Rogers 1995). Rural firms which operate in countries, whose societies are low in uncertainty avoidance, are more probable to take initiatives and innovate than imitate (Van den Bulte 2000; Dwyer et al. 2005) (H_5 is confirmed).

On the other hand, long term orientation is a determining factor of innovation for firms which are engaged in the NACE 02-03 sectors. This finding shows that farmers are willing to quit on their expectations in the present for the sake of better future earnings on their adoption in ICT tools (H_6 is confirmed).

Least but not last, firms in agrifood sector which belong to European countries tend to innovate more compared with other countries of the sample. The participation of countries in the European Union, facilitate the diffusion of innovations within their broad borders (Tellis et al. 2003). Furthermore, various organizations aid firms in the agrifood and agricultural sector to incorporate new technologies or improve the underlying ones; with respect to the specific challenges and needs of consumers in one integrated market (H_7 is confirmed).

Almost all research hypotheses are confirmed except for the effect that climate has on the propensity of innovation. Partly this finding is ought to the fact that the sample of countries

is consisted of countries with warm average daily air temperature and there are few countries in which there is cold climate.

The present study draws some findings which may be of interest for policy makers. For the firms, the adoption of websites along with a prosperous economic and cultural environment may lead to increased profitability. Through websites and assuming that consumers possess all the desirable characteristics, well stated by Rogers (1995), corporal activity is enhanced using online sales platforms (e.g. B2B or B2C) and firms tend to spend less for promotional activities. This effect may become multiplicative, if firms' profitability engaged in agrifood is reinvested so as to increase the propensity for innovation.

On the other hand, public policy makers may extract some useful conclusions from present study's findings. Even if the causal relationship between growth and expansion of agrifood sector is not investigated, the latter is of great importance for every nation, providing to residents the necessities. Public policy makers could take advantage of wealth, educated personnel, and several environmental and cultural characteristics that nations have so as to be introducing and eventually exporting new technology. This new technology could be adopted by countries in a borderless Europe, which encourages innovations from its members and diffuses it, either inside its territory or outside of it.

There are some limitations in the present study that needs to be reported. First, the dates from which adoptions of websites of each NACE classification for each country have been collected with the aid of Web Archive online tool, rather than an online database. Second, the number of countries, for which websites were adopted by firms, is rather limited, however this corresponds to the maximum number of firms included in the Orbis database. Third, for that reason estimation of Bass coefficients for innovation (p) and imitation (q) was conducted for time series concerning each country separately, and not with the use mixed effects.

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