https://doi.org/10.17221/154/2017-AGRICECON

Does higher food safety assurance bring higher returns? Evidence from Taiwan

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Jiang W.-J., Luh Y.-H. (2018): **Does higher food safety assurance bring higher returns? Evidence from Taiwan**. Agric. Econ. – Czech, 64: 477–488.

Abstract: With increasing concern of the food safety issue, consumer's demand for certified food have induced the adoption of organic farming or traceability certification. There is, however, relatively limited research devoted to examining the determinants and economic outcomes of the two food safety assurance certifications. The major intents of this study are to analyse the determinants of the farm household's adoption decisions of the organic and/or traceability certifications, and to investigate the economic consequences of different modes of adoption. It is found that while the log-odds of rice farmers' choice of organic certification over the choice of none of the certifications decreases significantly with age, the educational level is positively associated with the adoption of traceability certification. The results suggest the significance of the "Straybird Program", "One Hundred Young Farmers Counselling Program" and "The Farmers' Academy" in promoting the adoption of food safety assurance certification. Estimated average treatment effect after correcting for the self-selection problem indicates that the adoption of the traceability certifications leads to a better economic outcome for the Fuli rice farmers, compared with the adoption of organic or both certifications. This result thereby suggests that higher food safety assurance does not necessarily bring higher returns.

Keywords: determinants of adoption, economic consequences, Fuli rice farmers, organic certification, traceability certification

With an increasing consumer concern about food safety and ecological preservation, the administrative authorities in many countries require producers to adopt a sustainable food production practice (e.g. the European Union (EU), the United States of America (USA) and Japan). Among the few, organic farming is one of the promising alternatives. Therefore, there exists a large body of literature dealing with the consumers' awareness and willingness to pay (WTP) for organic products.

Among the many, Huang (1996) suggested that consumers with nutritional consciousness, concerns of the use of pesticides, and the awareness of freedom for residues will have a stronger propensity to buy organically grown products. In Thompson and Kidwell's (1998) study of consumers' choice between organic and conventional products, the results indicated that some of the shoppers are more likely to purchase organic products. Nonetheless, the demand side analysis for organic food may be over-optimistic if consumers' food safety awareness cannot induce a strong intention to purchase in reality (Pietola and Lansink 2001). Consequently, a supply side analysis considering both the cost and revenue associated with organic farming, i.e. an examination of the economic consequences of organic farming, is equally important in the process of promoting or developing the organic food industry.

In addition to organic certification, another effective solution to ensure food safety is the traceability system, which enables consumers to identify the history, location, movement, as well as the supply chain of the food. The outbreak of food safety incidents since the 1990s has led to the public's attention to food identity and the development of food traceability system. Accordingly, the demand side analysis of the traceability system found that consumers are willing to pay a premium for the traceability-certified products. In particular, Dickinson and Bailey (2002) and Hobbs et al. (2005) suggested that the combined traceability and other food safety assurance will lead to higher premiums.

Supported by the National Science Council in Taiwan, Grant No. 104-2410-H-002-017.

https://doi.org/10.17221/154/2017-AGRICECON

Another strand of research focused on examining the determinants of the producers' adoption decisions on organic farming (Burton et al. 1999; Genius et al. 2006; Kallas et al. 2010; Tiffin and Balcombe 2011) or the traceability system (Monteiro and Caswell 2009; Schulz and Tonsor 2010; Liao et al. 2011). There is, however, relatively limited research devoted to examining whether the certified organic or traceability farmers are better off than the conventional ones. One of the few exceptions is Uematsu and Mishra (2012), who indicated that organic farmers do not earn more income due to their higher production costs including labour, insurance and marketing charges. Motivated by the quite limited understanding of the impact of food safety assurance certification adoption on the farm household income, one of the goals of this study is to contribute to the literature by providing empirical evidence of differential economic consequences resulting from the adoption of organic and traceability certifications.

One unanswered question in the previous literature is whether a higher level of food safety assurance can bring a higher return. To our knowledge, none of the previous researches compared the economic consequences of adopting just one of the food safety assurance certifications with the farm operators' joint adoption of the organic and traceability certifications. To fill in this gap, the joint adoption behaviour of both organic farming and traceability certification analysis is based on a probabilistic-choice model.

Compared with the previous research, the different aspects of this study can be addressed from the following two perspectives. First, most studies on behaviour towards the adoption of certification have only considered a single food safety certification such as the Hazard Analysis and Critical Control Point (HACCP) (Henson and Holt 2000), traceability (Liao et al. 2011), ecological labels (Chang 2012), protected designation of origin (PDO) (Bouamra-Mechemache and Chaaban 2010) and organic (Uematsu and Mishra 2012), while the present study goes one step further by investigating the determinants of the joint adoption of organic and traceability certifications. Second, the present work seeks to quantify the economic impact of joint adoption of organic and traceability certificates for rice farmers in Taiwan. The analysis conducted in this study, therefore, adds to the literature by providing insights into the benefits of the joint adoption for small farm households.

Using field survey data from Taiwan, the present study attempts to answer the following questions: (i) What is the relationship between the adoption of certifications and producers' return? (ii) Which adoption is better for the producers, organic or traceability? (iii) Does a higher safety lead to a higher return when the producers can choose adopting organic and traceability certifications jointly?

THE ORGANIC FOOD SITUATIONS IN TAIWAN

Taiwan started to promote organic agriculture in 1996. To give a clear picture of the development of organic crops in Taiwan, Table 1 listed the planted area of four major crops in Taiwan including rice, vegetables, fruits and tea tree from 1996 to 2010. It is clear from Table 1 that rice has been the crop gaining the widest adoption of organic farming in Taiwan. However, the planted area of organic vegetables exhibited a faster increase lately, and therefore it exceeded the planted area of organic rice since 2010.

We report the planted area of organic rice from 1996 to 2012 in Table 2. With limited exceptions, the planted area of organic rice increased in an annual rate of double digits. Until the end of 2010, the planted area

Table 1. Planted area of organic crops in Taiwan (ha)

Year	Rice	Vegetables	Fruits	Tea trees	Other crops	Total
1996	62	26	67	5	–	160
2001	493	171	159	56	19	898
2002	–	–	–	–	–	–
2006	704	378	207	71	348	1 708
2007	843	438	258	125	349	2 013
2008	949	518	296	140	453	2 356
2009	1 085	913	289	169	504	2 960
2010	1 317	1 435	462	219	601	4 034

Source: Council of Agriculture of Taiwan (2017)

https://doi.org/10.17221/154/2017-AGRICECON

Table 2. Planting area and growth rate of organic rice

Year	Planting area			
	organic rice (ha)	growth rate (%)	conventional rice (ha)	% of organic rice to the total rice planting area
1996	62	–	34 799	0.02
1997	238	286.99	–	–
1998	302	26.89	–	–
1999	466	54.30	–	–
2000	596	27.95	–	–
2001	493	–17.25	33 218	0.15
2002	609	23.44	–	–
2003	600	–1.48	–	–
2004	744	23.95	–	–
2005	697	–6.22	–	–
2006	704	0.95	26 319	0.27
2007	842	19.66	–	–
2008	949	12.70	–	–
2009	1 085	14.26	–	–
2010	1 317	21.40	25 429	0.52
2011	1 654	25.57	26 079	0.63
2012	2 007	21.36	27 026	0.74

Source: Taiwan Organic Information Portal (2017), Council of Agriculture of Taiwan (2017)

of organic rice has reached the level of approximately 50% of all organic crops in Taiwan. In addition, the proportion of the planted area of organic rice to the total area of rice has been increasing at a steady rate since the year Taiwan started to promote the adoption of organic agriculture. The figures in Table 2 indicate that the percentage of organic rice increased from less than 0.1% to around 0.75% during the last two decades.

According to the FiBL-IFOAM Survey (2012), the largest ten countries with organic agricultural land in the year 2010 are China, India, Kazakhstan, Philippines, Indonesia, Sri Lanka, Saudi Arabia, Thailand, Timor-Leste and Pakistan. Taiwan was not among the largest ten organic countries during the year of the survey. However, when ranked in terms of the shares of organic agricultural land in Asia in the same year, the ten countries with the largest share are in order Timor-Leste, Palestine, Israel, Sri Lanka, South Korea, Philippines, Azerbaijan, India, Taiwan and China. Moreover, based on the 2010 "Agriculture, Forestry, Fishery and Animal Husbandry Census" (Yang 2013), data indicated that the market opportunities of organic agriculture in Taiwan include: (i) the nation-wide attention of food safety issues and health spending; (ii) the certified organic products can generate market segmentation; (iii) the price of organic product is less affected by the weather and thus shows a higher price stability; (iv) the organic product has a better and safer quality, which can lead to a higher international competitiveness. Therefore, the organic product has taken an increasingly important role in Taiwan's agricultural production over time.

The main country, Taiwan imports the organic product from, is the USA, with the import values of 18 and 17 million US dollars, respectively, in 2011 and 2014 (Jaenicke and Demko 2015). The second main country Taiwan imports the organic product from is the EU, which takes the share of 21% in Taiwan's total imports[1]. In Jaenicke and Demko (2015) study of the impacts from the organic equivalency policies between the USA and some countries including Taiwan is indicated that Taiwan signed a one-way equivalency agreement with the USA in 2009, which means that "Taiwan agreed to treat the United States Department of Agriculture (USDA) certified organic exports as organic in Taiwan without any additional certification" (Jaenicke and Demko 2015). Although the equivalency agreement between the USA and Taiwan is not reciprocal, it was predicted to generate about a 211% increase in the USA annual organic exports destined to Taiwan.

[1]This information comes from Taiwan's local report, please refer to Liberty Times (April 14, 2017) (Liberty Times 2017).

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It was indicated in Syu et al. (2014) that although the production and imports of organic products exhibited dramatic increases during the past decade in Taiwan, the exports of the organic products remained quite limited due to the lack of the two-way equivalency agreement with the American and European markets. The vice-president of the Council of Agriculture (COA) of Taiwan indicated that Taiwan has agreed to take the domestically-certified organic products from 22 countries including the Great Britain, France, Austria, Denmark, Finland, the Netherlands, Germany, Italy, New Zealand, Australia, Sweden, Luxembourg, Greece, Spain, Ireland, Belgium, Portugal, the USA, Canada, Switzerland, Hungary and Chile, as organic in Taiwan, but all of them are one-way equivalencies (Liberty Times 2017). Therefore, before signing up the two-way equivalency agreements with the USA, the EU or other countries, which can stimulate the organic product export, most of the organic products in Taiwan is for the domestic consumption at the present stage.

IDENTIFICATION STRATEGY

The empirical analysis of the determinants and economic consequences of the adoption decisions proceeds in two steps. Since the choice of certifications reveals the maximum utility, we first apply the random utility model proposed in McFadden (1974) and estimate the multi-nominal logistic model (MNL) to analyse the determinants of farm household's decisions of different modes of certifications. Based on the results from the first-stage estimation, the second identification strategy involves estimation of the economic consequences resulting from farm household's adoption decisions following the multinomial sample selection method (MSSM) proposed in Lee (1983).

Determinants of adoption decisions

The major focus of the present study is the adoption behaviour of Fuli rice farm households. Fuli rice is the rice produced in the Fuli township in Taiwan. According to the information provided by the Hualien Fuli township, the township is located in the middle of the East Rift Valley. The Fuli township is also the earliest rice cultivation area in the Eastern region of Taiwan. Fuli rice is the product from the "Kaohsiung 139" rice variety and has gained its visibility and reputation since exporting to Japan in 2005.

The farm households in our dataset are categorized into four groups. The four groups of farm household exhibit four mutually exclusive choices in terms of certification, which can be delineated by a random utility model proposed in McFadden (1974). Let j = 1 denotes the choice of neither organic nor traceability certification; j = 2 denotes the choice of adopting organic certification only; j = 3 denotes the choice of adopting traceability certification only; j = 4 denotes the choice of adopting both the organic and traceability certifications. U_{ij}^* is the indirect utility associated i^{th} farm household's j^{th} adoption mode. According to the random utility model, the farm household's decision concerning adoption results from the rational behaviour in pursing utility maximisation. Therefore, the farm household's choice of adoption (A) is as follows:

$$A_{ij} = 1 \text{ if } U_{ij}^* = \text{Max}\left(U_{i1}^*, U_{i2}^*, U_{i3}^*, U_{i4}^*\right)$$
$$= 0 \text{ otherwise} \quad (1)$$

where A_{ij} = 1 represents the i^{th} farm household's choice of adopting the j^{th} certification mode.

Since the indirect utility function is not observable, we further parameterise U_{ij}^* as a linear function of the explanatory variables,

$$U_{ij}^* = \mathbf{X}_i \boldsymbol{\beta}_j + \varepsilon_{ij},\ j = 1,2,3,4 \quad (2)$$

where $\mathbf{X}_i$ and $\boldsymbol{\beta}_j$ are, respectively, the vector of explanatory variables and the vector of coefficients in the j^{th} adoption equation. We assume that the disturbance terms (ε_{i1}, ε_{i2}, ε_{i3}, ε_{i4}) follow a multinomial logistic distribution, and thus the probability of adopting the j^{th} certification mode is as follows:

$$\text{Prob}\left(A_j = 1\right) = \frac{\exp\left(\mathbf{X}\boldsymbol{\beta}_j\right)}{1+\sum_{j=1}^{4}\exp\left(\mathbf{X}\boldsymbol{\beta}_j\right)},\ j = 2,3,4 \quad (3)$$

The probability for the first adoption mode A_1 = 1 is:

$$\text{Prob}\left(A_1 = 1\right) = \frac{1}{1+\sum_{j=1}^{4}\exp\left(\mathbf{X}\boldsymbol{\beta}_j\right)} \quad (4)$$

The multinomial logistic regression model is estimated by maximising the likelihood function (L):

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$$L = \sum_{i=1}^{n} \sum_{j=1}^{4} A_{ij} \times \log\left[\text{Prob}\left(A_j = 1\right)\right] \quad (5)$$

Economic consequences of the certification adoption

Our second identification strategy is to examine the impacts of different certification adoption modes on the farm household's economic performance, which is measured by the profit rate. Considering that the sample selection problem may lead to biased estimates using the traditional Ordinary Least Squares (OLS) regression, we use the multinomial logit OLS two-stage method proposed in Lee (1983) to address this issue.

Following Lee (1983), the MSSM is specified as:

$$\pi_{sj} = \mathbf{V}_s \boldsymbol{\gamma}_j + \Omega\, \rho_j \times \underbrace{\frac{\phi\left(\Phi^{-1}\left(F\left(\mathbf{X}_s \boldsymbol{\beta}_j\right)\right)\right)}{F\left(\mathbf{X}_s \boldsymbol{\beta}_j\right)}}_{\text{selection-correction term}} + \mu_{sj},\ j = 1,2,3,4 \quad (6)$$

where π_{sj} represents the profit rate of the s^{th} farm household adopting the j^{th} certification mode; $\mathbf{V}_j$ is a vector of determinants affecting profits and $\boldsymbol{\gamma}_j$ denotes a vector of parameters; F stands for function. In Equation 6, ϕ and Φ are the probability density function and the cumulative density function of normal distribution, respectively. Conditional on adopting the j^{th} certification mode, ρ_j is the correlation coefficient between the adoption equation and the income equation. Technically speaking, if the correlation coefficient ρ_j is sufficiently small, self-selection is not a serious problem; if it is not, then there is a need to correct for the self-selection bias to yield consistent estimates. The last term ($\phi(.)/F(.)$) in Equation 6 is referred to as the selection correction term.

Taking the farmer who adopts only organic certification as an example, the expected income associated with this adoption mode can be written as:

$$E\left(\pi_i \middle| A_{i2} = 1\right) = \mathbf{V}_i \boldsymbol{\gamma}_2 + \Omega\, \rho_2 + \frac{\phi\left(\Phi^{-1}\left(F\left(\mathbf{X}_i \boldsymbol{\beta}_2\right)\right)\right)}{F\left(\mathbf{X}_i \boldsymbol{\beta}_2\right)} \quad (7)$$

The procedure to estimate Equation 7 is as follows. In the first stage, we estimate the predicted probability of the multinomial logit model specified in Equation 3 and obtain the selection correction term. Then the OLS regression with the selection correction term as an additional independent variable is used to yield consistent estimates of Equation 7. The expected income for each of the other three types of adaption mode (including non-adaptors) is estimated similarly as in Equation 7.

Based on the estimates corrected for the sample selection bias, the effects of adopting only organic (A_2 = 1), only traceability (A_3 = 1) or both organic and traceability certifications (A_4 = 1) on the farmers' profit rate can be further calculated following the average treatment effect (ATE) method (Greene 2008):

$$\text{ATE}_j = E(\pi_{ji}) - E(\pi_{1i}),\ j = 2,3,4 \quad (8)$$

DATA AND DESCRIPTIVE STATISTICS

Data

The data used in this study are taken from the field survey of rice farmers in the Fuli Township of the Hualien County in Eastern Taiwan. One of the reasons for this choice of the rice farmer population is due to the fact that the Hualien County has nearly one half of the organic farms in Taiwan, and thus it is comparatively more representative than other areas. The other reason for conducting the rice farmer survey in the Fuli Township is due to the fact that in addition to being the major organic rice production area in Taiwan, the first organic village in Taiwan, Luoshan Village, is located in the Fuli Township.

The organic farmers surveyed in the present study are those affiliated with the Fuli Township organic production and marketing groups 1, 2 and 19. Considering the limited research funding and time constraint, the convenient sampling is the sampling method that is preferred by many of small-scale surveys in Taiwan. Based on the convenient sampling method, we collected a total of 184 samples. After excluding the invalid samples, there are in total 167 samples in our final data set.

In addition to the socio-economic characteristics of the rice farms and farmers, the survey questions include the farmer's attitude towards information, the perception of the feasibility of organic farming as well as the non-economic events motivating the farmer's adoption of organic farming. Since the economic consequences of adopting organic farming and/or traceability certification are the major topics of the present study, we base our investigation on the profit rate per unit of farmland as the economic con-

https://doi.org/10.17221/154/2017-AGRICECON

sequences resulting from the farmer's certification adoption behaviour.

Descriptive statistics

Table 3 reports the descriptive statistics of the farmer and farm characteristics. Among the total of 167 surveyed rice farmers, 63 of them (38%), adopt neither organic nor traceability certification. Next to that group of farmers are those that adopt only the traceability certification (31%), farmers that adopt both organic and traceability certifications (27%), and those adopt only organic certification (5%). On average, the profit rate is the lowest for the farms adopting both organic and traceability certifications, which is around 280 000 New Taiwan dollars (NTD), whereas the farms adopting only the traceability certification have the highest profit rate of around 510 000 NTD, followed by those adopting only the organic certification (around 350 000 NTD) and those who adopted neither organic nor traceability certification (around 320 000 NTD). The exchange rate in 2017 was 34.3 NTD = 1 EUR).

One of the socio-economic characteristics of the rice farmers is age. With an average age of 56 years, the rice farmers are a typical representation of the aging problem facing Taiwan's farm sector in general. Among the four groups of farmers, the average age of those adopting both certifications is around 61, which constitutes the group of the oldest farmers. Those adopting neither of the two certifications are the youngest, with an average age of 52 years. The farming experience is around 34 years in average for the full sample. In comparison, those adopting the organic certification or both certifications are the most experienced group, with the average farming experience of 40 years, whereas those adopting neither organic nor traceability certifications are the least experienced with the average of 28 years farming experience. The schooling years for the full sample are nine years, indicating that most of the sampled rice farmers have an educational level of the junior high school. The average area of farms is in order 5.38, 4.40, 3.6, and 3.56 akker (the unit of farm land used in Taiwan, which is equivalent to 0.97 hectare) for the group adopting the traceability certification only, adopting the organic certification only, adopting neither of the two certifications and adopting both certifications, respectively.

According to Tsai (2014), the Fuli County can be divided into four regions geographically. Region 4 in Table 3 is composed of four townships located in the central and northern part of the Fuli County. Different from the remaining three regions, rice produced from Region 4 is mostly from the conventional farming. We, therefore, include a dummy variable to capture the possible locational heterogeneity in the sample.

EMPIRICAL RESULTS AND DISCUSSION

Before discussing the empirical results, one digression of this paper from the existing research is the control of the three constructs other than the

Table 3. Descriptive statistics

Variable	Full sample	Not-certified	Traceability	Organic	Joint adoption
Not-certified*	0.38 (0.49)	–	–	–	–
Traceability*	0.31 (0.46)	–	–	–	–
Organic*	0.05 (0.21)	–	–	–	–
Joint adoption*	0.27 (0.45)	–	–	–	–
Profit (10 000 NTD)	37.03 (34.40)	32.49 (30.57)	51.49 (43.49)	35.24 (20.55)	27.64 (24.29)
Age (year)	55.74 (13.79)	52.29 (13.83)	55.49 (12.64)	57.38 (22.37)	60.58 (12.05)
Experience (year)	33.59 (19.90)	27.63 (19.95)	34.25 (17.65)	40.25 (24.70)	40.00 (19.52)
Education (year)	9.37 (3.16)	9.98 (3.00)	9.47 (3.38)	9.75 (4.46)	8.36 (2.69)
Land size (akker)	4.16 (4.05)	3.60 (3.77)	5.38 (4.97)	4.40 (2.73)	3.56 (3.23)
Region 4*	0.14 (0.35)	0.13 (0.34)	0.10 (0.30)	0.13 (0.35)	0.20 (0.40)
Number of observations	167	63	51	8	45

standard errors are in the parenthesis, the values in front of the parenthesis are means; *yes = 1, otherwise = 0; akker – 0.97 ha; NTD – New Taiwan dollars; Region 4 – a dummy variable that is equal to one if the household lives in the central and northern part of Fuli, otherwise, it is equal to zero

Source: this study

https://doi.org/10.17221/154/2017-AGRICECON

socio-economic factors shaping the farm household's attitudinal differences. The three constructs include the farm household's perceived feasibility and the ease of use of organic farming, health-related or environment-related concerns and events, as well as the attitude towards information acquisition.

Determinants of certification adoption

Table 4 reports the estimates of the multinomial logit model with the group of farmers adopting neither organic nor traceability certification as the reference group and the three conducts shaping farm household's attitude controlled. Consequently, the coefficients are interpreted in a relative sense. The meaning of one coefficient in the k^{th} adoption choice equation is a measure of the effect of the explanatory variable, on the probability of choosing the k^{th} adoption mode over the choice of the reference mode of choosing neither of the two certifications.

The first column in Table 4 suggests that the age of the major farm operator does not exhibit a statistically significant impact on the rice farm household's probability of adopting the traceability certification, over the probability of adopting neither of the two certifications. A similar result is observed for the case of adopting both certifications as reported in column 3. However, according to the figures reported in column 2, the age is found to have a negative impact on the rice farmers' probability of adopting only the organic certifications. If the major farm operator's age is increased by one year, the multinomial log-odds of choosing organic over choosing neither of the two certifications is predicted to decrease while holding all the other variables in the model constant. This result is consistent with the descriptive statistics reported in Table 3, which indicate that the organic farmers are older compared with those adopting neither of the two certifications.

Results in Table 4 show a similar impact of the major farm operator's years of farming experience. However, in contrast to the coefficient estimates for age, the results in the second column indicate that while holding all the other variables constant, the years of farming experience are found to increase the log-odds of the rice farmers' choice of the organic certification over the choice of none of the certifications. This result is consistent with our observation that relative to those adopting neither of the two certifications, farmers adopting organic farming only are in average more experienced.

Although the results in Table 4 indicate that the educational level and the land size are not important determinants of the farm household's adoption of either the organic certification or both of the two certifications over the choice of no certifications, the two variables are found to be the major determinants for the farm household's choice of the traceability certification. The major determinant of the farm household's choice of joint adoption over the choice of no certifications, however, is Region 4, which stands for the location of farmland in the northern and central part of the Fuli County.

Table 4. Estimates of the multinomial logit model (number of observations = 164)

Variable	Traceability	Organic	Joint adoption
Age (year)	0.04 (0.04)	–0.31*** (0.11)	–0.01 (0.04)
Experience (year)	0.01 (0.03)	0.26*** (0.06)	0.04 (0.03)
Education (year)	0.16* (0.10)	–0.02 (0.48)	–0.16 (0.14)
Land size (akker)	0.14** (0.06)	0.03 (0.19)	0.09 (0.07)
Region 4 (yes = 1; otherwise = 0)	–0.60 (0.87)	2.05 (2.19)	1.22* (0.73)
Constant	–2.26 (3.80)	–55.26*** (13.46)	–12.75** (4.98)
Control for attitudes			
Feasibility	Yes	Yes	Yes
Specific factors	Yes	Yes	Yes
Information acquisition	Yes	Yes	Yes

heterogeneity-robust standard errors are in the parenthesis, the values in front of the parenthesis are estimated coefficients; *, ** and *** represent p-value < 0.1, 0.05 and 0.01 (respectively); the group of farmers adopting neither traceability nor organic certification is the reference group; constant – the intercept term of the multinomial model; Region 4 – a dummy variable that is equal to one if the household lives in the central and northern part of Fuli, otherwise, it is equal to zero

Source: this study

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Marginal effects estimated from the multinomial logit model are reported in Table 5. Results in Table 5 suggest that once the major farm operator's age increases by one year, only the probability of adopting the organic farming (certification) is negatively affected by the size of 1%, whereas the remaining three modes of the certification adoption were not significantly affected in the statistical sense. This negative effect of the age variable on the adopting probability of organic farming in turn implies some of the recently implemented farm programs, such as the "Straybird Program" and "One Hundred Young Farmers Counselling Program", can also promote the farm operators' adoption of organic farming in addition to resolving the aging problem of the agriculture sector in Taiwan.

Years of farming experience, however, exhibit an effect with a similar size as the age variable while it works in the opposite direction. It is found that an increase of one year of the farming experience can raise the probability of adopting organic farming by 1%. This result suggests that more experienced farm operators more likely adopt organic farming.

Column 3 in Table 5 indicates that a one-year increase in the level of education will increase the farm household's adoption of the traceability certification by 3%. The possible explanation of the positive effect of the educational level may be due to the skills of or the familiarity with of the computer use required in the traceability system. In order to obtain the Taiwan/Traceability Agricultural Product (TAP) certification, the farm household needs to go through the checklist of the Taiwan Good Agricultural Practice (TGAP) and keep the record of the production process for at least some period of time. Since computer skills are needed in terms of the record keeping and the internet surfing leads to faster and easier information acquisition, the lack of the computer skills or other forms of human capital may thus dampen the probability of adopting the traceability certification.

There are two important determinants for the farm household's joint adoption of the organic and traceability certifications. The first determinant is the educational level measured by schooling years. The level of education is found to exert a negative effect on the farm household's probability of adopting both the organic and traceability certifications. Since, as previously discussed, farm operators with a higher educational level are more likely to adopt the traceability certification, part of their farm work time needs to be devoted to satisfying the requirement and standard of the TGAP. It is thus less likely for these farmers to simultaneously adopt organic farming, which also requires the devotion of more labour and work time to remove weeds in the farmland. The location of the farmland is also found to be a statistically significant determinant of the farm household's joint adoption of the organic and traceability certifications.

The land size is found to have a positive marginal effect on the farm household's adoption probability of the traceability certification. Nevertheless, no significant effect of the land size is found in the adoption of organic certifications. The explanation is as follows. As mentioned previously, organic farming requires intensive use of labour since without the use of chemical pesticides, weeds can only be removed through labour and insects can only be controlled through physical methods. When the land size increases, the probability of adopting organic farming may not increase due to the consideration of labour costs. Although the traceability certified rice also requires an additional input of labour for record keeping, its demand for labour is not as high as for the organic farming. Therefore, the farm household's adoption probability of the traceability certification may increase with the

Table 5. Estimates of the marginal effects

Variable	Not-certified	Traceability	Organic	Joint adoption
Age (year)	–0.00 (0.00)	0.01 (0.01)	–0.01*** (0.00)	0.00 (0.01)
Experience (year)	–0.01 (0.00)	–0.00 (0.00)	0.01*** (0.00)	0.00 (0.00)
Education (year)	–0.00 (0.02)	0.03** (0.01)	0.00 (0.01)	–0.03* (0.02)
Land size (akker)	–0.02** (0.01)	0.02** (0.01)	–0.00 (0.00)	0.00 (0.01)
Region 4	–0.04 (0.11)	–0.16 (0.12)	0.03 (0.04)	0.17* (0.09)

heterogeneity-robust standard errors are in the parenthesis, the values in front of the parenthesis are calculated marginal effects of the multinomial model; *, ** and *** represent p-value < 0.1, 0.05 and 0.01 (respectively); the group of farmers adopting neither traceability nor organic certification is the reference group; Region 4 is a dummy variable that is equal to one if the household lives in the central and northern part of Fuli, otherwise, it is equal to zero

Source: this study

https://doi.org/10.17221/154/2017-AGRICECON

Table 6. Economic outcomes of different adoption strategy

Variable	Two-stage estimation				
	OLS	not-certified	traceability	organic	joint adoption
Traceability (yes = 1, otherwise = 0)	4.17*** (1.34)	–	–	–	–
Organic (yes= 1, otherwise = 0)	−4.44** (1.85)	–	–	–	–
Joint adoption (yes = 1, otherwise = 0)	−5.19*** (1.49)	–	–	–	–
Age (year)	0.06 (0.07)	−0.08 (0.10)	−0.15 (0.20)	0.41 (0.61)	0.22* (0.12)
Experience (year)	0.03 (0.05)	0.06 (0.06)	0.22 (0.19)	−0.61 (0.49)	−0.01 (0.07)
Education (year)	0.16 (0.31)	−0.36 (0.51)	0.77 (0.58)	−1.07 (0.83)	0.49 (0.76)
Land size (akker)	8.19*** (0.18)	7.97*** (0.20)	8.73*** (0.28)	7.33* (1.14)	7.38*** (0.38)
Region 4	1.08 (2.08)	4.23 (2.76)	0.65 (5.24)	−3.88 (3.46)	−1.02 (2.89)
IMR1	–	2.15 (2.12)	–	–	–
IMR2	–	–	3.78* (2.06)	–	–
IMR3	–	–	–	2.99 (2.36)	–
IMR4	–	–	–	–	−1.30 (2.83)
Constant	−2.91 (5.39)	7.82 (8.32)	−5.33 (8.94)	12.23 (23.28)	−14.52 (10.19)
ATE	–	–	16.82*** (2.64)	1.34 (19.15)	−2.67 (4.25)
Number of observations	164	61	50	8	45

heterogeneity-robust standard errors are in the parenthesis (calculated using the Delta method), the values in front of the parenthesis are estimated coefficients; *, ** and *** represent p-value < 0.1, 0.05 and 0.01 (respectively); the group of farmers adopting neither traceability nor organic certification is the reference group; ATE – the average treatment effect; constant – the intercept term of the multinomial model; IMR – inversed Mill's ratio; OLS – ordinary least squares

Source: this study

land size considering the higher price margin of the traceability of certified rice in the rice market.

Economic effects

Table 6 reports both the results from the OLS and the two-stage estimations. The first column in Table 6 indicates that relatively to the group adopting neither of the two certifications, the adoption of the traceability certifications leads to an increase in the profit rate per akker. The marginal effect is around 41 700 NTD, which is around 11.26% of the average profit rate per akker for the full sample. The adoption of organic farming, however, is found to produce a negative impact on the profit rate per akker, by the size of nearly 45 000 NTD, which in turn suggests that the price margin of organic rice is not sufficient to make up for the increase in costs due to the adoption of organic farming.

Joint adoption of the organic and traceability certifications is found to result in, in average, a reduction in the profit rate per akker by around 52 000 NTD, which takes up nearly 14% of the average profit rate for the full sample and is greater than the reduction in profit rate for organic farmers. The OLS regression estimates thus indicate that the joint adoption of organic and traceability certifications result in a larger loss than adopting only organic farming. This result, in turn, suggests that a higher level of food safety assurance does not bring a higher return.

The MSSM estimates using the multinomial logit OLS two-stage method proposed in Lee (1983) are also reported in Table 6. The selection-correction term in Equation 6, i.e. the inversed Mill's ratio (IMR), IMR1–IMR4, are incorporated into the four adoption equations in the second stage estimation. A statistically significant estimate of the inversed Mill's ratio in one specific adoption equation implies the presence of the self-selection problem, which will lead to biased estimates when the traditional OLS method is used.

Two-stage estimates for the four different modes of certification adoption are reported in columns 2–5 in Table 6. Among the four bias-correction terms, only the estimate of the coefficient of IMR2 is statistically significant, suggesting the choice of adopting the

https://doi.org/10.17221/154/2017-AGRICECON

traceability certification is correlated with the error term of the farm household performance equation. A comparison of the estimates of the average treatment effect (ATE) from the MSSM (column 3) and the OLS (coefficient of traceability in column 1) suggests that the OLS estimation tends to underestimate the economic consequences of adopting the traceability certification.

On the other hand, after correcting for endogeneity, the average treatment effect of adopting traceability certification is 16.82 with a standard error of 2.64, which indicates that relative to the adoption of neither of the two certifications, the adoption of the traceability certification leads to an increase of the profit per akker by approximately 168 000 NTD. Moreover, the estimates of the ATE of the adoption of only the organic certification or both the organic and traceability certifications are, respectively, 1.34 and –2.67, which are not statistically significant from zero. The result suggests that the negative estimates of the ATE for the two adoption modes are overestimated using OLS.

CONCLUSION

With increasing concern of the food safety issue, the consumer's demand for the certified food has induced the adoption of organic farming or the food traceability certification. One of the major intents of this study is to analyse the determinants of the farm household's adoption decisions of the organic/traceability certifications. To this end, the joint adoption behaviour of both organic farming and the traceability certification is treated as one particular adoption decision among the four exclusive choices. The present study moves on to the investigation of the economic consequences of different adoption modes, relative to the case of the uncertified rice produced in the conventional farming, in an intention to test the working hypothesis that a higher food assurance brings a higher return.

Some important policy implications can be inferred from the present study. One of our major findings is that with the increase in the farm operator's age, the log-odds of rice farmers' choice of organic certification over the choice of none of the certifications will decrease significantly. This result implies that the recently implemented "Straybird Program" and "One Hundred Young Farmers Counselling Program", which intend to resolve the aging problem of the agriculture sector in Taiwan, can instead promote the farm operators' adoption of organic farming.

The level of education is found to be an important determinant of the farm household's adoption of the traceability certification. The positive association of the educational level and the adoption of traceability certification has an important policy implication for the programs aiming at raising the farmer's computer skills and the use of the internet. Since 2011, Taiwan implemented the program called "The Farmers' Academy" which offers online training courses to farmers. The results in this study suggest the significance of similar programs in the government's efforts in promoting the adoption of the traceability certification.

To correct the self-selection problem, we apply the multinomial logit OLS two-stage method proposed in Lee (1983) to obtain estimates of the economic consequences of different certification adoption modes. The estimate of the average treatment effect of adopting the traceability certification indicates that, relative to the adoption of neither of the two certifications, the adoption of the traceability certification leads to an increase in profit. The estimates of the average treatment effect of the adoption of only the organic certification or both the organic and traceability certifications, however, are not statistically significant from zero. That is, the economic outcomes of rice produced with a higher food safety assurance are not different from the conventional farming. Compared with the traceability certified rice, organic rice or rice certified by both organic and traceability certifications represent a higher food safety assurance. Therefore, our results suggest that a higher food safety assurance does not lead to a higher return (profits per akker) for the rice producers in Taiwan. Although this result cannot be generalised to all Good Agriculture Practice (GAP) certifications, the evaluation framework proposed in this paper has practical implications for providing a cornerstone in the process of promoting different food safety assurance certifications in the future.

Adopting organic and traceability certifications can lead to an additional cost for producers in Taiwan. On the one hand, the organic-certified crop producers incur higher opportunity costs such as the additional labour expenses, insurance and marketing charges (Uematsu and Mishra 2012). The farmers participating in a traceability program are required to pay a fee that varies according to the type of products. The traceability-certified producers also bear internal costs

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such as the payment for recording and documenting the detailed information of the entire production process (Chang 2012). However, there are benefits the farmers can obtain from the adoption since the consumers exhibit a higher willingness to pay (WTP) for the certified products. Accordingly, rice producers could suffer the risk from losses if the consumers' WTP does not compensate for the increased costs of adoptions. The findings in the present study thus echo the view of Suri (2011) that the adoption decisions can be appropriately explained by the net benefits of the adoption.

Acknowledgements

Seniority is shared by the two authors. The authors thank M.-H. Tsai for his great efforts in conducting and collecting the survey data used in the present study. Supported by the National Science Council in Taiwan (Grant No. 104-2410-H-002-017).

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Received May 29, 2017
Accepted August 30, 2017
Published online November 12, 2018