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Determinants of Product Innovation Implementation in Japanese Agricultural Corporations

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Innovation, an important component of productivity growth, is expected to contribute significantly toward changing rural and agricultural structures. The first step in understanding innovation implementation is to identify its driving factors. However, these factors remain unclear in the context of agricultural corporations. Therefore, this study aims to identify the factors associated with the product innovation implementation in Japanese agricultural corporations. A probit model was used to identify these driven factors by using the data of 308 corporations from the national survey in 2019. The results showed that 20.5% (n=63) of corporations were rice corporations. Most corporations (38.6%, n=199) generated an annual sales revenue of 100 to 300 million yen. Further, 50.0% of corporations implemented product innovation, that is, these corporations started to produce and sell new or significantly improved goods or launched new or significantly improved services. The results also show that corporations that generate high annual sales, seek high number of sales, aim for profit margins of 5–15%, and believe more strongly in their ability to innovate tend to implement product innovation. Contrastingly, corporations that have a profit margin between 1% and 10% are less likely to implement product innovation than those breaking even. Corporations that mainly deal in facility vegetables or livestock products also tend to implement product innovation less than the corporations mainly selling rice. Overall, the results suggest that a certain level of annual sales might be required for innovation, and innovating farms seek growth and set high targets. Therefore, to promote product innovation in Japanese agricultural corporations, these factors should be considered.

Key words: agricultural innovation adoption, Japanese agricultural corporation, product innovation implementation

INTRODUCTION

Japanese agricultural management has been described as smaller in scale compared to Europe and the US. However, the percentage of Japanese agricultural corporations out of the total agricultural management is nearly the same as that of Germany and higher than that of Switzerland, France, Spain, and Italy (Nanseki, 2019, p.337). In such agricultural corporation management, aside from the introduction of information communications technology (ICT) in production management and business management, innovations such as processing and direct sales of agricultural goods that were produced are being promoted. Such innovative practices may significantly impact agricultural and rural structures in the future. Nanseki (2021) showed the state of innovation implementation in Japanese agricultural corporations using four types of innovation: product, process, marketing, and organizational innovation, as classified by OECD (2005). All of them were adopted by less than 50% of agricultural corporations. Most corporations (41.9%) implemented product innovation, particularly "producing and selling new or significantly improved goods".

Therefore, it is important to understand the factors driving the adoption of these innovations to enhance innovation implementation and change agricultural structures. In this regard, Feder *et al*. (1985) reviewed the factors affecting innovation adoption in agriculture at the micro–level, using individual technologies as a proxy for agricultural innovations. Läpple *et al*. (2015) and Castillo–Valero and García–Cortijo (2021) presented such factors by treating innovation adoption in agriculture as overall innovation adoption However, studies that consider innovation adoption in Japanese agricultural corporations as overall innovation and do not specify individual innovations do not exist to the best of our knowledge. Moreover, among the four types of innovation, product innovation is adopted by most Japanese agricultural corporations (Nanseki, 2021) as well as by Japanese firms (OECD, 2009). Therefore, this study aims to determine the factors associated with the implementation of product innovation in Japanese agricultural corporations.

The next section describes data collection and the empirical model. It is followed by the Results and Discussion section, which presents general information on Japanese agricultural corporations and the factors affecting the implementation of product innovation. The final section concludes the paper.

The results in this paper were previously presented

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orally at the 10th Asian Society of Agricultural Economics International Conference (Nguyen *et al*., 2021)

DATA AND METHODOLOGY

Data

The data for this study was collected from the "Questionnaire on Business Development and Innovation in Agricultural Corporation Management," conducted by the authors in 2019 by mailing the questionnaire on agricultural corporations nationwide to 2,885 corporations. They collected the names of such corporations by independently searching the related websites (such as the Japan Association of Agricultural Corporations) and existing literature. By December of the same year, responses were received from 505 corporations (response rate: 17.5%). However, the number of valid answers to each item varied. An outline of the survey's results is presented in Nanseki (2021). Product innovation was divided into two categories in the questionnaire: (1) starting to produce and sell new or significantly improved goods and (2) launching new or significantly improved services. Notably, 504 corporations answered for the first category, and 505 corporations answered for the second one. However, the number of valid observations with the available data of all the variables used for analysis of this study was 308.

Empirical model

This study used the following probit model to determine whether a corporation implemented product innovation.

$$Y^* = \beta_0 + X\beta + e, \quad (1)$$
$$with\ Y = 1\ if\ Y^* > 0\ and\ Y = 0\ if\ Y^* \leq 0.$$

Here, Y^* is an unobserved or latent variable, and Y is an observed variable of Y^*. Y=1 if the corporation implemented product innovation that means that the corporation started to offer new or significantly improved goods or services and 0 otherwise. X is the full set of explanatory variables that include a range of characteristics of agricultural corporations, such as main product, sales and profit, self–evaluation of their ability to innovate, and their representative's profile (Table 1). Further, β represents the set of parameters, and e is independent of X and has a standard normal distribution.

RESULTS AND DISCUSSION

Characteristics of Japanese agricultural corporations and their implementation of product innovation

The result of the basic analysis showed that the rate of implementing product innovation in Japanese agricultural corporations was 50.0% (n=154) (Table 2). This finding suggests that 50.0% of corporations started to provide at least one of the two following types of product innovation: new or significantly improved products or services in the three years before the survey. More details on the distribution of corporations implementing product innovation based on their categories are shown in an appendix (Table 4). Notably, corporations implement product innovation in different ways. Some product innovations can be creating food–residue–based feed, Omega–3 eggs in livestock corporations, the rice turned into ready–to–eat meals, or rice corporations cultivating a new variety. Some corporations may launch innovative services such as direct selling to cafeterias, providing tourist farms, paying the hometown tax, organizing events at farm stores, creating farmers' markets, and offering guidance on GLOBALG.A.P.

Regarding the characteristics of agricultural corporations shown in Table 2, some common characteristics are observed as follows. A total of 86.1% of the corporations (n=265) were stock companies and limited companies established on the guidelines of the Companies Act. A total of 89.9% of the corporations (n=277) were qualified to own agricultural land. Although agricultural corporations were established based on various backgrounds, particularly those from non–agricultural sectors that recently joined the agriculture sector. Notably, 41.6% of the corporations (n=128) originated from a farmer who had established a one person corporation. Corporations that began with a farmer jointly establishing the corporation with other members followed next (28.6%, n=88). Considering sales revenue as an economic indicator, most corporations (38.6%, n=119) earned 100 to 300 million yen in sales revenue, followed by the corporations generating 50 to 100 million yen (22.7%, n=70). Interestingly, 243 corporations (78.9%) had sales revenue up to 300 million yen. However, 85.3% of corporations (n=269) aimed to achieve at least 1.2 times their current sales in the next five years. This finding suggests that future sales will see a significant change. Furthermore, most corporations (33.8%, n=104) seek a profit margin of 5–10%. In addition, paddy rice accounted for more than 60% of most corporations' total annual sales (20.5%, n=63), followed by facility vegetables and mixed products (14.3%, n=44 and 11.7%, n=36, respectively).

Corporations were asked to evaluate whether their ability to produce new products or technologies is stronger or weaker than that of others. Resultingly, the mean value of this self–evaluation was 2.805 on a scale ranging from 1 (weaker than others) to 5 (stronger than others). This result indicates that, on average, corporations perceive their ability to innovate at a level lower than neither weaker nor stronger than the ability of others. Of these, 69 corporations (22.4%) evaluated this ability as being at least slightly stronger than that of others.

The study also collected data on the representatives of corporations, particularly their age, education, and non–agricultural experience. Notably, their ages varied from 20 to over 70 years old, with most representatives (35.7%, n=110) between the ages of 60 and 70. Their education was analyzed based on different levels. Most representatives (53.2%, n=164) completed high school,

Table 1. Description of variables

No	Variable	Description	Unit	Expected sign	Reference
I	**Dependent variable**				
	Product innovation (PI)	It equals one if a corporation started to produce and sell new or significantly improved goods or products, and/or launched new or significantly improved services in the three years before the survey. Otherwise, it equals zero.	Dummy		
II	**Independent variables**				
1	Type of corporation	There are four types of corporations. 1 = Limited company; 2 = Stock company; 3 = Agricultural producers' cooperative corporation; 4 = Others.	Categorical	+/–	
2	Own land	It equals one if a corporation is qualified to own farmland. Otherwise, it equals zero.	Dummy	+	
3	Region	The region where the head office is located. There are seven regions. 1 = Hokkaido; 2 = Tohoku; 3 = Kanto; 4 = Hokuriku; 5 = Kinki and Tokai; 6 = Chugoku and Shikoku; 7 = Kyushu and Okinawa.	Categorical	+/–	
4	Age of corporation	The number of years since the establishment of the corporation.	Years	+/–	Ns: Castillo–Valero and García–Cortijo (2021)
5	Agricultural experience of corporation	The number of years since the corporation started engaging in agricultural activities.	Years	+/–	
6	Background of corporation	There are seven categories. 1 = A farmer established the corporation of only one person corporation; 2 = A farmer jointly established the corporation with other members; 3 = A Farmer established the corporation in collaboration with non–farmers and companies from other industries; 4 = A non–farmer entered agriculture as an individual and established the corporation; 5 = The company mainly deals in a separate/different business, but it has entered agriculture as a new business; 6 = The parent/main company or group company has established a new corporation and entered agriculture; 7 = Others.	Categorical	+/–	
7	Regular employees	The total number of regular employees in the corporation.	Persons	+	Castillo–Valero and García–Cortijo (2021); Hashi and Stojčić (2013) as firm size
8	Annual sales	The sales revenue generated in latest accounts before the survey. 1 = Less than 30 million yen; 2 = 30–50 million yen; 3 = 50–100 million yen; 4 = 100–300 million yen; 5 = 300–500 million yen; 6 = 500–1000 million yen; 7 = 1000–1500 million yen; 8 = 1500–2000 million yen; 9 = Over 2000 million yen.	Categorical	+	+ Läpple *et al.* (2015) in terms of farm area
9	Profit margin	The profit margin earned in latest accounts before the survey. 1 = 0% (Break–even); 2 = 1–5%; 3 = 5–10%; 4 = 10–15%; 5 = 15–20%; 6 = Over 20%; 7 = Deficit.	Categorical	+/–	
10	Growth stage	The corporation's growth stage. 1 = Starting; 2 = Growing; 3 = Mature; 4 = Recession; 5 = 2nd starting; 6 = 2nd growing; 7 = 2nd mature; 8 = 2nd recession; 9 = Others.	Categorical	+/–	
11	Sales target	The sales the corporation aims to earn in the next five years compared to their current sales. 1 = Same; 2 = 1.2 times; 3 = 1.5 times; 4 = 1.8 times; 5 = 2.0 times; 6 = Over 2 times but less than 3 times; 7 = 3 times or more; 8 = Lesser; 9 = No target.	Categorical	+	
12	Profit margin target	The profit margin the corporation aims to achieve in the next five years. 1 = 0% (Break–even); 2 = 1–5%; 3 = 5–10%; 4 = 10–15%; 5 = 15–20%; 6 = Over 20%; 7 = No target.	Categorical	+/–	
13	Main product	It represents the agricultural product that accounted for more than 60% of the corporation's total annual sales. There are 14 categories: 1 = Paddy rice; 2 = Wheat; 3 = Beans and coarse cereals; 4 = Open ground vegetable; 5 = Facility vegetable; 6 = Flowers and foliage plants; 7 = Fruiter; 8 = Mushroom; 9 = Livestock products; 10 = Mixed; 11 = Others.	Categorical	+/–	
14	Self–evaluation in new product and technology development	Self–evaluation of the ability to innovate. 1 = Weaker than others; 2 = Slightly weaker than others; 3 = Neither weaker nor stronger than others; 4 = Slightly stronger than others; 5 = Stronger than others.	Likert scale	+	
15	FTA participation	Self–evaluation of the Free Trade Agreements (FTA) participation of Japan. 1 = Big crisis; 2 = Crisis; 3 = Neither crisis nor chance; 4 = Chance; 5 = Big chance.	Likert scale	+/–	

16	Age of representative	The age of the corporation's representative. 1 = 10–20; 2 = 20–30; 3 = 30–40; 4 = 40–50; 5 = 50–60; 6 = 60–70; 7 = Over 70.	Categorical	–	Läpple *et al.* (2015), Feder *et al.* (1985)
17	High school	If the corporation's representative graduated high school, it equals one. Otherwise, it equals zero.	Dummy	+/–	
18	Vocational school	If the corporation's representative graduated vocational school, it equals one. Otherwise, it equals zero.	Dummy	+/–	
19	Educational institution	If the corporation's representative graduated from an educational institution, it equals one. Otherwise, it equals zero.	Dummy	+/–	
20	Junior college	If the corporation's representative graduated junior college, it equals one. Otherwise, it equals zero,	Dummy	+/–	
21	University	If the corporation's representative graduated university, it equals one. Otherwise, it equals zero.	Dummy	+/–	
22	Graduate school	If the corporation's representative graduated from graduate school, it equals one. Otherwise, it equals zero.	Dummy	+/–	
23	Other type of education	If the corporation's representative completed some other type of education, it equals one. Otherwise, it equals zero.	Dummy	+/–	
24	Non–agricultural experience of representative	The values range from 1 to 6: 1 = None; 2 =1–5 years, 3 = 5–10 years; 4 = 10–15 years; 5 = 15–20 years; 6 = 20–25 years.	Categorical	+/–	+ (Feder *et al.*, 1985); – (Läpple *et al.*, 2015)

Note: +, –, and Ns indicate positive, negative, and non–significant effects on innovation implementation, respectively.
Categorical variables 1, 3, 6, 8, 9, 10, 11, 12, and 13 show the effect of other groups of the variable with the first group as the reference.
Categorical variables 16 and 24 are treated as continuous variables.

Table 2. Descriptive results on the implementation of product innovation and explanatory variables

No	Variable	Unit	Mean	Std. Dev	Min	Max	Numbers of corporations
I	**Dependent variable**						
	Product innovation (PI)	Dummy	0.500	0.501	0	1	154
II	**Independent variables**						
1	Type of corporation	Categorical					
	1 = Limited company		0.416	0.494	0	1	128
	2 = Stock company		0.445	0.498	0	1	137
	3 = Agricultural producers' cooperative corporation		0.130	0.337	0	1	40
	4 = Others		0.010	0.098	0	1	3
2	Own land	Dummy	0.899	0.301	0	1	277
3	Region	Categorical					
	1 = Hokkaido		0.026	0.159	0	1	8
	2 = Tohoku		0.192	0.394	0	1	59
	3 = Kanto		0.143	0.350	0	1	44
	4 = Hokuriku		0.101	0.301	0	1	31
	5 = Kinki and Tokai		0.127	0.333	0	1	39
	6 = Chugoku and Shikoku		0.166	0.372	0	1	51
	7 = Kyushu and Okinawa		0.247	0.432	0	1	76
4	Age of corporation	Years	20.110	14.196	1	109	–
5	Agricultural experience of corporation	Years	30.734	31.687	0	319	–
6	Background of corporation	Categorical					
	1 = A farmer established the corporation of only one member corporation		0.416	0.494	0	1	128
	2 = A farmer jointly established cooperation with other members		0.286	0.452	0	1	88
	3 = A farmer established the corporation in collaboration with non–farmers and companies from other industries.		0.039	0.194	0	1	12
	4 = A non–farmer entered agriculture as an individual and established a corporation.		0.055	0.229	0	1	17
	5 = The company mainly deals in a separate/different business, but it has entered agriculture as a new business.		0.075	0.263	0	1	23
	6 = The parent/main company or group company has established a new corporation and entered agriculture.		0.084	0.278	0	1	26
	7 = Others		0.045	0.209	0	1	14
7	Regular employees	Persons	17.045	35.348	1	352	–
8	Annual sales	Categorical					
	1 = Less than 30 million yen		0.075	0.263	0	1	23
	2 = 30–50 million yen		0.101	0.301	0	1	31

	3 = 50–100 million yen		0.227	0.420	0	1	70
	4 = 100–300 million yen		0.386	0.488	0	1	119
	5 = 300–500 million yen		0.075	0.263	0	1	23
	6 = 500–1000 million yen		0.049	0.216	0	1	15
	7 = 1000–1500 million yen		0.039	0.194	0	1	12
	8 = 1500–2000 million yen		0.016	0.127	0	1	5
	9 = Over 2000 million yen		0.032	0.178	0	1	10
9	Profit margin	Categorical					
	1 = 0% (Break–even)		0.104	0.306	0	1	32
	2 = 1–5%		0.321	0.468	0	1	99
	3 = 5–10%		0.192	0.394	0	1	59
	4 = 10–15%		0.127	0.333	0	1	39
	5 = 15–20%		0.042	0.201	0	1	13
	6 = Over 20%		0.019	0.138	0	1	6
	7 = Deficit		0.195	0.397	0	1	60
10	Growth stage	Categorical					
	1 = Starting		0.081	0.274	0	1	25
	2 = Growing		0.347	0.477	0	1	107
	3 = Mature		0.179	0.384	0	1	55
	4 = Recession		0.068	0.252	0	1	21
	5 = 2nd starting		0.149	0.357	0	1	46
	6 = 2nd growing		0.120	0.326	0	1	37
	7 = 2nd mature		0.042	0.201	0	1	13
	8 = 2nd recession		0.003	0.057	0	1	1
	9 = Others		0.010	0.098	0	1	3
11	Sales target	Categorical					
	1 = Same		0.127	0.333	0	1	39
	2 = 1.2 times		0.318	0.467	0	1	98
	3 = 1.5 times		0.273	0.446	0	1	84
	4 = 1.8 times		0.029	0.169	0	1	9
	5 = 2.0 times		0.120	0.326	0	1	37
	6 = Over 2 times but less than 3 times		0.055	0.229	0	1	17
	7 = 3 times or more		0.058	0.235	0	1	18
	8 = Lesser		0.010	0.098	0	1	3
	9 = No target		0.010	0.098	0	1	3
12	Profit margin target	Categorical					
	1 = 0% (Break–even)		0.058	0.235	0	1	18
	2 = 1–5%		0.214	0.411	0	1	66
	3 = 5–10%		0.338	0.474	0	1	104
	4 = 10–15%		0.195	0.397	0	1	60
	5 = 15–20%		0.120	0.326	0	1	37
	6 = Over 20%		0.055	0.229	0	1	17
	7 = No target		0.019	0.138	0	1	6
13	Main product	Categorical					
	1 = Paddy rice		0.205	0.404	0	1	63
	2 = Wheat		0.003	0.057	0	1	1
	3 = Beans and coarse cereals		0.010	0.098	0	1	3
	4 = Open ground vegetable		0.110	0.314	0	1	34
	5 = Facility vegetable		0.143	0.350	0	1	44
	6 = Flowers and foliage plants		0.039	0.194	0	1	12
	7 = Fruiter		0.097	0.297	0	1	30
	8 = Mushroom		0.036	0.186	0	1	11
	9 = Livestock production		0.146	0.354	0	1	45
	10 = Mixed		0.117	0.322	0	1	36
	11 = Others		0.094	0.293	0	1	29
14	Self–evaluation in new product and technology development	Likert	2.805	1.025	1	5	–
	1 = Weaker than others		0.110				34
	2 = Slightly weaker than others		0.253				78
	3 = Neither weaker nor stronger than others		0.412				127
	4 = Slightly stronger than others		0.169				52
	5 = Stronger than others		0.055				17
15	FTA participation	Likert	2.851	1.003	1	5	–
	1 = Big crisis		0.104				32
	2 = Crisis		0.214				66

	3 = Neither crisis nor chance		0.471				145
	4 = Chance		0.149				46
	5 = Big chance		0.062				19
16	Age of representative	Categorical	5.292	1.199	2	7	–
	1 = 10–20		0.000				0
	2 = 20–30		0.003				1
	3 = 30–40		0.081				25
	4 = 40–50		0.198				61
	5 = 50–60		0.208				64
	6 = 60–70		0.357				110
	7 = Over 70		0.153				47
17	High school	Dummy	0.532	0.500	0	1	164
18	Vocational school	Dummy	0.094	0.293	0	1	29
19	Educational institution	Dummy	0.143	0.350	0	1	44
20	Junior college	Dummy	0.049	0.216	0	1	15
21	University	Dummy	0.321	0.468	0	1	99
22	Graduate school	Dummy	0.032	0.178	0	1	10
23	Other type of education	Dummy	0.026	0.159	0	1	8
24	Non–agricultural experience	Categorical	3.328	1.980	1	6	–
	1 = None		0.250				77
	2 = 1–5 years		0.198				61
	3 = 5–10 years		0.140				43
	4 = 10–15 years		0.081				25
	5 = 15–20 years		0.049				15
	6 = 20–25 years		0.282				87

Source: Nanseki (2021); n = 308; $1~109 yen (in 2019 from https://www.stat–search.boj.or.jp/ssi/cgi–bin/famecgi2)

99 representatives (32.1%) graduated from university and 44 (14.3%) from an educational institution. Furthermore, 29 representatives (9.4%) completed vocational school, 15 (4.9%) attended junior college, followed by 10 (3.2%) who finished graduate school, and 8 (2.6%) who gained some other type of education. Finally, 75% of them (n=231) had at least one year of experience in non–agricultural activities.

Determinants of implementing product innovation

The objective of this study is to unfold the factors driving the implementation of product innovation in Japanese agricultural corporations by the characteristics of agricultural corporations and the profile of corporation representatives. The results are presented in Table 3.

First, the value of the likelihood ratio chi–square was 116.2 and significant at the 1% level. This finding sug-

Table 3. Factors associated with the implementation of product innovation

No	Variable	Coef.		Std. Err	z	P>|z|	[95% Conf. Interval]	
1	Type of corporation (1 = Limited company is the base group)							
	2 = Stock company	–0.011		0.238	–0.050	0.964	–0.477	0.455
	3 = Agricultural producers' cooperative corporation	–0.005		0.348	–0.010	0.989	–0.688	0.678
	4 = Others	–0.429		1.105	–0.390	0.698	–2.595	1.738
2	Own land (Dummy)	0.151		0.342	0.440	0.660	–0.520	0.821
3	Region (1 = Hokkaido is the base group)							
	2 = Tohoku	0.156		0.617	0.250	0.800	–1.054	1.366
	3 = Kanto	0.394		0.633	0.620	0.533	–0.846	1.635
	4 = Hokuriku	1.169	*	0.676	1.730	0.084	–0.157	2.494
	5 = Kinki and Tokai	1.064		0.657	1.620	0.105	–0.224	2.352
	6 = Chugoku and Shikoku	0.207		0.628	0.330	0.741	–1.023	1.438
	7 = Kyushu and Okinawa	0.424		0.607	0.700	0.485	–0.766	1.615
4	Age of corporation (Years)	0.000		0.009	–0.030	0.978	–0.017	0.017
5	Agricultural experience of corporation (Years)	–0.001		0.003	–0.470	0.637	–0.008	0.005
6	Background of the corporation (1= A farmer established the corporation of only one member/single corporation is the base group)							
	2 = A farmer jointly established the cooperation with other members	0.182		0.263	0.690	0.490	–0.334	0.697
	3 = A Farmer established the corporation in collaboration with non–farmers and companies from other industries	–0.867		0.546	–1.590	0.113	–1.937	0.204
	4 = A non–farmer entered agriculture as an individual and established the corporation	–0.680		0.504	–1.350	0.178	–1.668	0.309

	5 = The company mainly deals in a separate/different business, but it has entered agriculture as a new business	–0.477		0.479	–0.990	0.320	–1.416	0.463
	6 = The parent/main company or group company has established a new corporation and entered agriculture	0.138		0.414	0.330	0.739	–0.673	0.949
	7 = Others	–0.366		0.524	–0.700	0.484	–1.393	0.660
7	Regular employees (Persons)	–0.002		0.004	–0.460	0.648	–0.011	0.007
8	Annual sales (1 = Less than 30 million yen is the base group)							
	2 = 30–50 million yen	0.289		0.484	0.600	0.550	–0.660	1.238
	3 = 50–100 million yen	0.493		0.422	1.170	0.243	–0.334	1.319
	4 = 100–300 million yen	0.517		0.409	1.260	0.207	–0.285	1.318
	5 = 300–500 million yen	1.883	***	0.588	3.200	0.001	0.730	3.036
	6 = 500–1000 million yen	1.557	**	0.655	2.380	0.017	0.273	2.840
	7 = 1000–1500 million yen	–0.827		0.783	–1.060	0.291	–2.362	0.708
	8 = 1500–2000 million yen	1.406		0.890	1.580	0.114	–0.338	3.150
	9 = Over 2000 million yen	1.671	*	0.889	1.880	0.060	–0.070	3.413
9	Profit margin (1 = 0% (Break–even) is the base group)							
	2 = 1–5%	–0.796	**	0.350	–2.280	0.023	–1.481	–0.111
	3 = 5–10%	–1.208	***	0.394	–3.070	0.002	–1.979	–0.436
	4 = 10–15%	–0.615		0.443	–1.390	0.165	–1.484	0.254
	5 = 15–20%	–0.564		0.546	–1.030	0.302	–1.634	0.507
	6 = Over 20%	–1.156		0.867	–1.330	0.182	–2.856	0.543
	7 = Deficit	–0.551		0.369	–1.490	0.136	–1.275	0.174
10	Growth stage (1 = Starting is the base group)							
	2 = Growing	–0.249		0.417	–0.600	0.550	–1.067	0.569
	3 = Mature	–0.344		0.473	–0.730	0.468	–1.271	0.584
	4 = Recession	–0.271		0.557	–0.490	0.626	–1.363	0.820
	5 = 2nd starting	0.014		0.492	0.030	0.978	–0.950	0.977
	6 = 2nd growing	–0.825		0.504	–1.640	0.102	–1.813	0.163
	7 = 2nd mature	–0.716		0.674	–1.060	0.288	–2.038	0.605
	8 = 2nd recession	0.000		(empty)				
	9 = Others	–0.068		0.867	–0.080	0.937	–1.768	1.631
11	Sales target (1 = Same is the base group)							
	2 = 1.2 times	0.186		0.334	0.560	0.577	–0.468	0.841
	3 = 1.5 times	0.665	*	0.374	1.780	0.075	–0.068	1.398
	4 = 1.8 times	1.774	**	0.738	2.400	0.016	0.328	3.220
	5 = 2.0 times	0.782	*	0.445	1.760	0.079	–0.091	1.655
	6 = Over 2 times but less than 3 times	0.584		0.564	1.030	0.301	–0.522	1.690
	7 = 3 times or more	1.056	*	0.577	1.830	0.067	–0.076	2.187
	8 = Lesser	0.310		1.171	0.270	0.791	–1.985	2.606
	9 = No target	0.000		(empty)				
12	Profit margin target (1 = 0% (Break–even) is the base group)							
	2 = 1–5%	0.270		0.498	0.540	0.587	–0.705	1.246
	3 = 5–10%	0.880	*	0.497	1.770	0.077	–0.094	1.854
	4 = 10–15%	1.056	*	0.540	1.950	0.051	–0.003	2.115
	5 = 15–20%	0.544		0.589	0.920	0.355	–0.610	1.699
	6 = Over 20%	0.814		0.652	1.250	0.211	–0.463	2.092
	7 = No target	0.164		1.008	0.160	0.870	–1.811	2.140
13	Main product (1 = Paddy rice is the base group)							
	2 = Wheat	0.000		(empty)				
	3 = Beans and coarse cereals	2.037	*	1.128	1.810	0.071	–0.174	4.248
	4 = Open ground vegetable	–0.629		0.403	–1.560	0.118	–1.419	0.160
	5 = Facility vegetable	–0.771	*	0.403	–1.920	0.055	–1.561	0.018
	6 = Flowers and foliage plants	0.488		0.624	0.780	0.434	–0.734	1.710
	7 = Fruiter	0.484		0.416	1.160	0.244	–0.331	1.299
	8 = Mushroom	0.887		0.582	1.530	0.127	–0.253	2.027
	9 = Livestock production	–0.752	*	0.430	–1.750	0.081	–1.596	0.092
	10 =Mixed	–0.142		0.357	–0.400	0.691	–0.842	0.558
	11 = Others	0.043		0.397	0.110	0.913	–0.735	0.822
14	Self–evaluation in new product and technology development	0.323	***	0.106	3.050	0.002	0.115	0.531
15	FTA participation	0.056		0.099	0.570	0.570	–0.138	0.251
16	Age of representative	–0.043		0.092	–0.470	0.640	–0.223	0.137
17	High school	–0.114		0.227	–0.500	0.616	–0.559	0.331
18	Vocational school	–0.430		0.334	–1.290	0.198	–1.085	0.225

19	Educational institution	–0.387	0.333	–1.160	0.246	–1.041	0.266
20	Junior college	0.102	0.441	0.230	0.818	–0.762	0.965
21	University	–0.112	0.251	–0.450	0.655	–0.603	0.380
22	Graduate school	–0.128	0.568	–0.220	0.822	–1.241	0.986
23	Other type of education	–0.646	0.722	–0.890	0.371	–2.061	0.770
24	Non–agricultural experience	–0.022	0.063	–0.350	0.730	–0.145	0.101
	Constant	–1.576	1.288	–1.220	0.221	–4.100	0.948

Source: Nanseki (2021); n = 303[a]; $1~109 yen (in 2019 from https://www.stat–search.boj.or.jp/ssi/cgi–bin/famecgi2)
Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10%, respectively; Log likelihood = –151.921; LR Chi–Square (73) = 116.2***; Pseudo R^2 = 0.277; percent correctly classified = 72.9%.
[a] Five observations were not used in the probit model because they belonged to the categories that predict failure/success perfectly.

Table 4. Distribution of corporations implementing product innovation (PI) based on their category

Category	Description	Frequency	Percentage
PI_only product	If a corporation started providing only new or significantly improved products, it equals one. Otherwise, it equals zero.	105	34.1
PI_only_services	If a corporation started providing new or significantly improved services, it equals one. Otherwise, it equals zero.	16	5.2
PI_both product and service	If a corporation started providing new or significantly improved products and services, it equals one. Otherwise, it equals zero.	33	10.7
PI_None	If a corporation had not yet started to provide new or significantly improved products and services, it equals one. Otherwise, it equals zero.	154	50.0
Total		308	100.0

Source: Nanseki (2021); n = 308

gests that the current estimated model is statistically significantly better than a model without any explanatory variables. Moreover, the pseudo R^2 was 0.277, and the correctly classified percentage was 72.9%.

Second, factors determining the implementation of product innovation in Japanese agricultural corporations can be observed in Table 3. The sign of the coefficients showed the relationship between the variable and innovation implementation. If the sign of a coefficient is positive, it means that one unit increase in the variable will increase the probability of implementing the product innovation in agricultural corporations. Conversely, if the sign of a coefficient is negative, it means that a one–unit increase in the variable will reduce the probability of implementing the product innovation. However, all continuous variables are non–significant in this study. The categorical variables are transformed into dummy variables and expressed conditionally in the base group, which is the first group in the categories. Table 3 shows that the coefficients of three categories under the variable Annual sales (300–500 million yen, 500–1000 million yen, and over 2000 million yen) were significantly positive. This finding signifies that corporations whose sales revenue stands between 300 million yen and 1 billion yen and those earning more than 2 billion yen tend to implement product innovation more than those generating sales revenues lower than 30 million yen. From this result, it can be concluded that higher annual sales amount of the corporation as an economic scale factor contributed to the likelihood of innovation implementation. This finding was consistent with that of Läpple *et al*. (2015), who found that larger–sized farms tend to implement innovation more, measuring farm size by the utilizable agricultural area However, our conclusion does not hold for all categories denoting high sales revenues.

Notably, the coefficients of four categories under the variable Sales target, namely 1.5 times, 1.8 times, 2.0 times, and 3.0 times or more, were significantly positive. This finding indicates that corporations seeking sales higher than 1.5 times their current sales in the next five years are more likely to adopt product innovation than corporations wanting their sales to remain the same. However, corporations seeking sales 2 times more but less than 3 times their current sales are exceptions to this result. Furthermore, the coefficients of target profit at 5–10% and 10–15% were significantly positive as well (Table 3). This result suggests that corporations targeting profit margins between 5% and 15% have a higher probability of implementing product innovation than corporations seeking to break even. The final variable that had a significantly positive coefficient was Self–evaluation in new product and technology development. It means that the corporations that self–evaluated themselves as being more strong than others tend to implement more product innovation. It is a reasonable result because corporations that find their ability to innovate as being strong can innovate their products and engage more in innovative practices (Sauer and Vrolijk, 2019).

Contrastingly, the coefficients of profit margin from 1–5% and 5–10% were significantly negative. This shows that corporations with a profit margin of 1–10% are less likely to implement product innovation than corporations breaking even. The coefficients of facility vegetable and livestock products as corporations' main

products were also significantly negative. This implies that the corporations mainly dealing in facility vegetables or livestock tend to not implement the production innovation than those whose main product is rice.

The results discussed above show that all determinants of implementing product innovation pertain to the characteristics of corporations. That is, the profile of the representative does not affect the implementation. Especially, age had no effect, considering that the aging population is a crucial concern in Japanese agriculture. This result differs from that of previous studies (Läpple *et al*., 2015; Feder *et al*., 1985), which found that older farmers tend to adopt fewer agricultural innovations and technologies. They show that old farmers believe that innovating might not be effective at their age, considering the time and money invested and the payoff from innovating. In this regard, this study shows that the representative's age does not deter the corporation because the corporation could continue its business more easily (MAFF, 2019).

CONCLUSION

To summarize, product innovation is implemented by 50.0% of Japanese agricultural corporations. They continue to multiply because of easier employment and business continuity (MAFF, 2019). Moreover, they have changed the agricultural sector. Especially, the rate of implementing product innovation of the Japanese agricultural corporations tends to increase in corporations generating sales revenues between 300 million yen to less than 1 billion yen and those with sales from 2 billion yen and above. Corporations targeting more than 1.5 times their current sales tend to implement product innovation more than those seeking the same as their current sales. However, corporations that aim for more than two times but less than three times their current sales are exceptions. Corporations with a target profit margin of 5–15% are more likely to implement product innovation than those intending to break even.

Overall, these results imply that: (1) corporations might require suitable annual sales to innovate; (2) innovating farms aim to grow and set high targets.Therefore, these factors should be considered to promote product innovation in Japanese agricultural corporations. The researchers intend to expand their research to other types of innovation (process, marketing, and organizational) in the future to present the determinants of implementing agricultural innovation extensively.

AUTHOR CONTRIBUTIONS

All listed authors have contributed to this manuscript. Nguyen Thi Ly carried out the study's design, statistical analysis, and drafted the manuscript. Nanseki Teruaki designed the questionnaire, assisted in data collection, supplied data sources, designed the study, advised on data interpretation, and edited the manuscript. Chomei Yosuke designed the questionnaire, assisted with data collection, the study design, advised on data interpretation, and edited the manuscript. Uenishi Yoshihiro and Mi Jie assisted with the study design, advised on data interpretation, and edited the manuscript. All the authors have read and approved the final manuscript.

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