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Factors affecting the use of artificial insemination of farmers in dairy farming

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Abstract

The study was carried out in the districts of Harmacık, Keles, Orhaneli and Büyükorhan known as the mountain region of Bursa province, Turkey with the purpose of determining factors affecting farmers' use of artificial insemination in dairy farming. The number of the farms was determined using a stratified random sampling method. The data were collected from 252 dairy cattle farms between April and December 2018. The study employed the logit model to evaluate the data. The results revealed that the educational level of the farmers, dairy farming experience, the number of dairy cattle, livestock diseases, off-farm income, artificial insemination support and access to veterinary services variables had a positive effect on farmers' use of artificial insemination; whereas age and household size variables had a negative impact. As a result, the use of artificial insemination in dairy farm can be increased with farmers who are open to innovations regarding livestock activity and knowledgeable about artificial insemination.

Keywords: Artificial insemination, Dairy cattle, Income, Logit model

Introduction

Livestock sector has socio-economical contributions such as providing employment for households living in rural area, supplying raw materials to different sectors, and increasing national income (Aksoy et al., 2011). Thus, it is critically important for the sustainability of livestock activities that farms keep up with the recent changes by following innovations and developments. The methods and techniques used in livestock activities vary in time depending on the developments in the sector. However, to keep up with these changes, farmers need to give up old methods used in livestock and adopt the innovations in a short time (Sezgin et al., 2010). Furthermore, it is rather important in this sector to have fertile breeds, and to increase the number of the healthy animal. Therefore, it can be said that artificial insemination (AI) is one of the key practices in livestock sector. It is a technique aimed at improving all breeds of animals. Particularly used as a reproduction method in dairy farming, AI provides significant economic contributions to milk production and to farmers by genetically improving animals (Howley et al., 2012). In Turkey, AI efforts began in 1926, and was used for domestic cattle and sheep breeds from 1926 to1936. Both private sectors and public institutions were entitled to use AI as per the 1985 regulations. All these developments accelerated the studies related to this technique and it made widespread (Gençdal et al., 2015). In Turkey, it is estimated that the number of AI implemented in 2018 was about 2.8 million. Bursa province is the 4th biggest city of Turkey, located in the northwest of Turkey and the southeast of the Marmara Sea. The province has a great potential in terms of livestock and animal production due to its economic structure and geographical features. In Bursa province, there has been significant increases in the culture breeds in animal population, especially in the recent years. Bursa province ranks 28th in Turkey in terms of the number of bovine animals. In 2018, this

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ratio was 72.4% in Bursa province while the share of culture breeds (dairy cattle) was 48.9% in Turkey. In the same year, the number of AI was 81,146 in Bursa province (TURKSTAT, 2018). With its significant location for dairy farming, Bursa province includes the following districts, which are known as the mountain region: Harmancık, Keles, Orhaneli and Büyükorhan. The majority of the households in these districts live on agriculture and livestock (Karahan et al., 2015). Bovine animals in these four districts respectively constitute about 1.1%, 1.9%, 5.2% and 4.3% of the bovine animals in total in Bursa province. Therefore, four districts in the mountain region make significant contributions to livestock farming. Although there are many studies on AI in the literature, there is a limited number of studies aimed at determining of the factors affecting farmers' use of AI and their decision-making trends regarding this technique (Kaaya et al., 2005; Sezgin et al., 2010; Howley et al., 2012; Gençdal et al., 2015). Besides, there is no comprehensive study conducted in these four districts in relation to this subject. For this reason, it is important to evaluate the factors that have an impact on farmers' decision-making trends on the use of AI for improving dairy farming activities in the research area. Therefore, the purpose of the present study is to determine the factors that impact on farmers' use of AI in these four districts known as the mountain region. To elaborate on the issues that serve the purpose of the study, this study tests the following hypotheses:

H_0=Institutional services, socio-economical and farm characteristics have no significant effect on farmers' use of AI

H_1= Institutional services, socio-economical and farm characteristics have a significant effect on farmers' use of AI

The precautions to increase milk yield in dairy cattle farms, which constitute an important portion of the livestock sector, is essential for the sustainability of farms. Therefore, it is necessary to increase the number of healthy and fertile animals in farms. This study, which offers some significant insights into the factors affecting the farmers' use of AI, is of great importance for this research field. The results of this study will potentially contribute to livestock activities in Bursa province and its districts, and to other studies in the relevant literature.

Material and Methods

The Study Area and Sample Size

This study was based on the data obtained from dairy cattle farms in the districts of Harmancık, Keles, Orhaneli and Büyükorhan of province of Bursa in Turkey, which are known as the mountain region, through survey method between April and December, 2018. The data were collected by face-to-face interviews with farmers. A total of 3,505 farms involved in dairy farming activities were the target population of the research. The number of animals in farms was considered in determining the sample size. The farms were selected by the stratified random sampling method. The sample size was calculated using the Neyman method (Sezgin et al., 2010; Yamane, 1967). This method is as follow;

$$n=\frac{(\sum N_h\ S_h)^2}{N^2D^2+\sum N_hS_h^2} \quad , \qquad D^2=d^2/z^2 \qquad [1]$$

where, n is the sample size (252 farms), N is the number of dairy cattle farms in the districts (3,505 farms), N_h is the number of dairy cattle farms in the h stratum; S_h is the standard deviation for the h stratum, S_h^2 is the variance for h stratum, d is desired absolute precision, z is desired confidence level (1.96 for 95%), D is acceptable error limit in population mean. Farms were divided into three groups as 2 to ≤11 cattle (67 farms), 12 to <21 cattle (53 farms) and equal 22 and >22 cattle (132 farms). The total sample size was calculated as 252 dairy farms. However, all farms were included in the evaluation because there were not important differences between the farms in the strata.

Econometric Model

This study determined the socio-economical characteristics of the farmers through descriptive statistics. The logit model was also used in the identification of the factors affecting farmers' decision-making trends for the use of AI. Logistic regression is non-linear a model which can be linearization with designed transformations for the binary dependent variable, and dependent variable represents the occurrence or non-occurrence of an event (coded as 1 or 0). The logit model is one of methods used to estimate of the binary dependent variable models (Yohannes, 2014). The dependent variable that indicates the farmers' use of AI was divided into two response categories as the farmers who use AI (coded 1= event) and those who do not use AI (coded 0= no event) according to the logit model. The STATA statistical analysis program was utilized in the analysis of the data (StataCorp, 2005). This model is defined as follows:

$$P_i=\frac{1}{1+e^{-(\beta_0+\beta_iX_i)}}=\frac{1}{1+e^{-(Z_i)}} \qquad [2]$$

where, is dependent variable, P_i is the probability of use AI for the i[th] farmers and it ranges from 0-1, is constant term, =parameter to be estimated, X_i=independent variables. Based on the natural log of this equation (2), the following equation can be written:

$$L_i=\ln\left[\frac{P_i}{1-P_i}\right]=Z_i=\beta_0+\beta_1X_1+....+\beta_kX_k \qquad [3]$$

McFadden's pseudo R-squared value and the likelihood ratio (LR) were calculated to the goodness of fit of the model and its explanatory power. McFadden's pseudo R-squared value can be as low as 0 but can never be equal to 1, and parameter values between 0.2 and 0.4 contain a reference to an appropriate model fit (Karahan et al., 2015). The likelihood ratio chi-square (LR chi^2) is defined as -2 (L_0- L_1), where L_0 describes the log likelihood for the constant only model and L_1 is the log likelihood for the full model with constant and predictors (Yohannes, 2014). When the LR statistic value of the model is greater than the value of chi-square, the null hypothesis (H_0) is rejected.

Definition of Variables

The dependent variable of the logit model has two response categories. To determine the dependent variable, the farmers were asked if they use AI or not. Accordingly, these results were combined into a dummy variable; if the farmer do not use AI, this is given the value of 0 (0=no event) and the value of 1 is given when the farmer uses AI (1=event). The independent variables included in the model were selected from some studies in the literature (Tefera et al., 2014; Gençdal et al., 2015). Age is one of the important demographic characteristics affecting farmers' behaviors. Because, farmers' preferences may change depending on their age. Old farmers are more likely to refuse innovations on agriculture and livestock compared to younger or middle-aged farmers to avoid the risks of new technologies (Yohannes, 2014). Therefore, the increasing age is expected to negatively affect the farmers' use of AI. Education enhances the ability of farmers to use their knowledge (Paulos et al., 2004). Since the more educated farmers are, the more successful they are in adapting to innovations and developing skills. Therefore, it is expected that educational level of the farmers has a positive effect on the farmers' use of AI. Experience is an important factor for farmers. Because, the farmers with knowledge and experience in dairy farming activities may find it easier to adapt to new technologies (Yohannes, 2014). Thus, it is expected that the farmers with more experiences are more likely to use AI and thus, experience in dairy farming may have a positive impact on the farmers' use of AI. The likelihood to use AI also depends on the increase in the number of animals and the income level of the farmers. Hence, the use of AI may decrease depending on the increase in the total number of dairy cattle, particularly in the farms with a low income. So, the higher the number of animals in these farms is, the less likely the farmers use AI. Yet, the farmers with a middle or high income and an additional income may prefer to use AI to maintain the health of their animals and to ensure herd management (Yohannes, 2014). Thus, the higher the number of animals in these farms is, the more likely the farmers use AI. It is expected that the number of dairy cattle may have a positive or negative impact on the farmers' use of AI. Household size plays an important role in the decision-making process of the farmers on the use of any technological innovations or practices in their farms. Since the increase or decrease in the number of family members in a household can affect the tendencies of the farmers towards the adoption of new technologies (Bamire et al., 2002). Particularly small family farms are by nature subsistence farms. Therefore, when the number of family member in a household increases, the farmers use their income to meet the needs of these family members rather than buying new technologies. Hence, it is expected that the number of the farmers using AI decreases depending on the increase in the number of family members in the household. Livestock diseases are substantially important for dairy cattle farms because farmers often face with various animal diseases in their farms. Farmers encounter problems such as loss of income and production due to animal deaths caused by diseases. Therefore, it is expected that the farmers use AI more often to maintain herd management and to prevent animal diseases in their farms. Thus, in this model, the variable of livestock diseases takes values as 1 for the farmer faced with epidemic diseases and as 0 for those who do not. Farmers need an off-farm income in order to boost their income level. Additional income can enhance the financial strength of farmers and the opportunities to use new technologies (Yohannes, 2014). Therefore, farmers may follow innovations on livestock depending on the increase in income in their farms. Hence, the likelihood of the farmers with an off-farm income to use AI is expected to be high. Thus, in this model, the variable of off-farm income takes values as 1 for the farmers with an off-farm income and as 0 for those who do not. It can be said that farmers benefit from various livestock supports. AI is one of these supports that benefit by farmers. This support is key in ensuring the sustainability of livestock activities and protecting the farmers. Because, it can significantly increase the animal production in farms. Thus, the farmers who benefit from this support are expected to have an increasing tendency to use AI. Therefore, in this model, the variable of artificial insemination support takes values as 1 for the farmers who benefit from this support and as 0 for those who do not. Having access to veterinary services is an important for a healthy and productive livestock farming (Oladele et al., 2013). Since these services can reduce the productivity losses and economic losses in production. For this reason, farmers need to easily access to veterinary services. Thus, it is assumed that the farmers' use of AI may increase with the provision of easy access to veterinary services. Therefore, in this model, the variable of access to veterinary services takes values as 1 for the farmers who have easy access and as 0 for those who do not.

Results and Discussion

In this study, the ratio of the farmers who use AI was 85.3% and those who do not use AI was 14.7%. Similarly, the ratio of the farmers using AI was determined as 49%, 50.3%, 54.5%, 75.2% and 56%, respectively, in some studies (Howard and Cranfield, 1995; Aksoy et al., 2011; Özyürek et al., 2014; Gençdal et al., 2015). According to these results, it can be said that the ratio of AI use in the four districts known as the mountain region is higher than the ratio found in previous studies. This result shows that the tendencies of the farmers to use AI are high and they hold positive opinions regarding this technique. The socio-economical characteristics of the farmers were explained by descriptive statistics (Table 1). It was found that 38.1% of the farmers were aged between 26-36 and the average age was 40.8. In studies conducted in province of Van in Turkey and Uganda, the average age of the farmers was reported to be 45.0 and 44.5, respectively (Kaaya et al., 2005; Gençdal et al., 2015). Thus, it can be said that the results of this study are congruent with the findings of previous studies. Educational level is one of the most important demographic features affecting the farmers' behaviors, and their preferences may change depending on their educational level. It was found that the majority of the farmers (72.2%) attended primary education and the average year of schooling was 6.2 in this study. In the studies conducted by Kaaya et al. (2005) and Gençdal et al. (2015), it is reported that the average year of schooling of the farmers was 10.3 years and 4.5 years, respectively. Therefore, the average year of schooling of the farmers in this study is lower than the value reported by Kaaya et al. (2005) and higher than the value explained by Gençdal et al. (2015). Also, 55.6% of the farmers had a household size of 3-4 persons and the average household size was 3.1 persons. Thus, it can be said that this value is below the average household size (3.5 persons) at the national level. It was found that 58.7% of the farmers had a dairy farming experience of 11-20 years and the average experience was 15.1 years. In studies conducted by Howard and Cranfield (1995), Kaaya et al. (2005) and Gençdal et al. (2015) found that the dairy farming experience of the farmers was 16.5 years, 19 years and 25 years, respectively. Thus, the results of this study on the dairy farming experience are lower than those obtained from previous studies. Furthermore, it was found that 15.1% of the farmers had the highest income (≥€5512).

Table 1. Socio-economical, farm characteristics and institutional services (n=252)

Characteristics	Frequency	%	Mean	**SD
Farmers' age (year)				
26-36	96	38.1	40.78	9.85
37-47	86	34.1		
48-58	60	23.8		
≥59	10	4.0		
Education level (year)				
Primary school graduate	182	72.2	6.25	2.29
Secondary school graduate	42	16.7		
High-school graduate	23	9.1		
University graduate	5	2.0		
Household size (person)				
≤2	80	31.7	3.10	1.05
3-4	140	55.6		
≥4	32	12.7		
Farmers' dairy farming experience (year)				
≤10	59	23.4	15.10	5.59
11-20	148	58.7		
≥20	45	17.9		
*Household income (€ year^{-1})				
≤€2718.5	66	26.2	€3639.8	1036
€2719-€5511.8	148	58.7		
≥€5512	38	15.1		
Number of dairy cattle (head)				
2≤11	67	26.6	21.38	14.70
12-21	53	21.0		
≥21	132	52.4		
Livestock diseases				
Yes	181	71.8	0.72	0.45
No	71	28.2		
Off-farm income				
Yes	204	81.0	0.81	0.39
No	48	19.0		
Artificial insemination support				
Yes	229	90.9	0.91	0.29
No	23	9.1		
Access to veterinary services				
Yes	224	88.9	0.89	0.31
No	28	11.1		

*1 Euro=5.31 TRY (Turkish lira) in June 2018, **SD=Standart deviation

In this study, the McFadden's pseudo R-squared value and likelihood ratio (LR) were calculated to test the goodness of fit of the established model and its explanatory power. The LR and chi-square statistic (chi^2) values were calculated as 72.15 and 16.92, respectively. The null hypothesis at 5% significance was rejected because the LR value was found to be greater than chi^2 value. The McFadden's pseudo R-squared value was calculated as 0.34. These results revealed that the model is statistically significant and fits for the study (Table 2).

Table 2 presents the parameter estimates of the logit model employed to identify the factors affecting the farmers' use of AI. According to these results, it was found that age had a negative effect on farmers who use AI at 1% level of significance. Hence, it can be said that institutional services, farm and socio-economical and farm characteristics have a significant effect on the farmers' use of AI. Thus, a one-year increase in the age of the farmer would decrease the likelihood that the farmer uses AI by 9.92%. The relevant results revealed that old farmers are more likely to refuse innovations on livestock compared to their young or middle-aged counterparts. In this regard, the majority of the farmers using AI were young and middle-aged, and the variable of age was effective in the preferences of farmers on new practices. Thus, these results are congruent with the findings from the studies of Sezgin et al. (2010) and Howley et al. (2012), but are not with those from Howard and Cranfield (1995), Tambi et al. (1999) and Kaaya et al. (2005), which indicated that there was a positive relationship between the farmers' age and the use of AI. Therefore, it is essential that old farmers in the research area are informed on AI to ensure herd management and to enhance their yields from dairy cows and their tendencies to use such techniques are increased.

Table 2. Factors affecting farmers' use of artificial insemination

Variables	Coefficient	Standart Error	z-statistic	p-value>|z| (probability)	Marjinal Effects
Age of farmers	-0.2159	0.0386	-5.59	0.000**	-0.0992
Educational level	0.4710	0.1355	3.48	0.001**	0.0216
Dairy farming experience of farmers	0.1282	0.0514	2.50	0.013*	0.0059
Number of dairy cattle	0.0514	0.0191	2.70	0.007**	0.0024
Household size	-0.8953	0.2541	-3.52	0.000**	-0.0411
Livestock diseases	1.3958	0.5255	2.66	0.008**	0.0884
Off-farm income	1.1030	0.5210	2.12	0.034*	0.0707
Artificial insemination support	2.1729	0.6525	3.33	0.001**	0.2277
Access to veterinary services	1.5044	0.6486	2.32	0.020*	0.1208
Constant	3.3771	1.3780	2.45	0.014*	
McFadden's pseudo R-squared =0.34			log likelihood (L_0)= -105.12499		
log likelihood (L_1)= -69.05208			likelihood ratio (LR)=72.15		
Prob>chi square (chi^2)=0.000(Probability)			$LR>chi^2(9)_{(0.05)}$ = 72.15>16.92		

The levels of significance: *p<0.05; **p<0.01

Educational level had a positive influence on the farmers using AI at 1% level of significance. Thus, a one-year increase in the school education of farmers would increase the probability of the use of AI by 2.16%. These results show that the number of the farmers using AI may increase depending on increase in their education and knowledge level. These findings are consistent with the findings of the study conducted by Gençdal et al. (2015), which concluded that there was a positive relationship between the farmers' educational level and the use of AI, but are not congruent with those of Tefera et al. (2014). Thus, AI practices are preferred by the farmers with a high educational level more than others in the farms in the research area.

The dairy farming experience had a positive influence on the farmers using AI at 5% level of significance. Thus, a one-year increase in dairy farming experience would increase the probability of the use of AI by 0.59%. The preferences of the farmers on AI may change due to the increase in their knowledge and experiences depending on their dairy farming experiences. Similar findings were obtained from study conducted in Kenya (Tambi et al., 1999). The findings of this study are not congruent with the results of the studies conducted in Uganda and in Canada, which reported that there was a negative relationship between the dairy farming experiences of the farmers and the use of AI (Howard and Cranfield, 1995; Kaaya et al., 2005). Thus, the probability of the use of AI may increase with the improved knowledge and skills due to increased dairy farming experiences in the farms.

The number of dairy cattle had a significant positive influence on the farmers who use AI at 1% level of significance. Thus, a one-unit increase in the number of dairy cattle would increase the probability of the use of AI by 0.24%. Therefore, it can be said that AI is preferred more by the farmers with a middle and high income, as well as an additional income, compared to other farmers. Although these results are not congruent with the findings of Tefera et al. (2014), which indicated that there was a negative relationship between the number of dairy cattle that the farmers had and the use of AI, the present results are similar with the findings of the study conducted in Ireland (Howley et al., 2012). Thus, it is expected that an increase in the number of the farmers using AI to increase milk yield and to protect the health of animals in the farms depends on the increase in the number of dairy cattle.

Household size had a significant negative effect on the farmers using AI at 1% level of significance. Thus, an increase in the household of the farmers by one person would decrease the probability of the use of AI by 4.11%. Thus, the larger the household is, the less likely the farmers use AI. When the number of family member in a household increases, the farmers use their income to meet the needs of these family members rather than buying new technologies. Therefore, household size is significant for the farms. Similar results were obtained by Asfaw et al. (2011). The results of the present study are not congruent with the results of Aksoy et al. (2011), which indicated that there was a positive relationship between the number of persons in the family and the use of AI. Thus, the negative effects of household size on the adoption of innovations by the farmers may decrease with the precautions taken to increase the income level and milk yield of the farmers in the farms.

Livestock diseases had a significant positive effect on the farmers who use AI at 1% level of significance. Thus, the probability of the use of AI increases by 8.84% for the farmers who face with epidemic diseases compared to others. Because, it can be said that farmers take various measures to protect the herd health in their farms. AI, which is one of these measures, may be more preferable by farmers who have encountered with epidemic diseases, and so the probability of the use of AI is higher in the farms that have faced with epidemic diseases. Because, losses of production and income negatively affect the income of farmers.

Off-farm income had a significant positive effect on farmers the using AI at 5% level of significance. The probability of the use of AI increases by 7.07% for the farmers with an additional income compared to others. According to these results, off-farm income had a significant positive effect on the farmers using AI. In other words, the farmers who have an off-farm income can increase likely to use AI. Because, these income can increase the tendencies of the farmers to use new technologies (Yohannes, 2014). Therefore, farmers need off-farm income. These results are in line with the findings of Mal et al. (2012) and Beshir et al. (2012). Thus, most of the farmers in the research area have an off-farm income besides an on-farm income.

Artificial insemination support had a significant positive effect on the farmers who use AI at 1% level of significance. The probability of use of AI increases by 22.77% for the farmers who receive such support compared to others. According to these results, artificial insemination support had a significant positive effect on the farmers who use AI. In other words, the farmers who benefit from this support are expected to have an increasing tendency to use AI. Furthermore, AI is critical to protect consumers and ensure sustainable livestock activities. One of the most important purposes of this support is to increase profitability. For this reason, AI is required to convert the existing breeds into high-yielding breeds (Demir and Yavuz, 2010). Thus, benefiting from this support increases the number of the farmers using AI.

Access to veterinary services had a significant positive effect on the farmers using AI at 5% level of significance. Thus, the probability of the use of AI increases by 12.08% for the farmers who have easy access to these services compared to others. According to these results, access to veterinary services had a significant positive effect on the farmers using AI. Veterinary services prevent diseases from spreading to animals, and from animals to humans (Oladele et al., 2013). Therefore, it can be argued that it is key for farmers to benefit from these services. Gaining an easy access to veterinary services means that farmers an also easily benefit from AI service. The results of the present study are not congruent with the findings of Gençdal et al. (2015), which indicated that there was a negative relationship between the distance from farm to the district and the possibility of AI use. Therefore, providing an easy access to veterinary services can increase the number of the farmers using AI.

Conclusion

In conclusion, it is essential to make AI more popular in the districts of Bursa province that old farmers are informed on AI and its importance, that financial capacities are reinforced by increasing the income obtained from off-farm activities, and that farmers are provided with the access to veterinary services in the shortest time possible and the supports on AI are improved. In other words, the farmers who are knowledgeable on AI, open to innovations on livestock activities, and aware of the fact that AI is key for a profitable farming can reduce the ratio of low-yielding breeds and increase the use of AI in farms.

Compliance with Ethical Standards

Conflict of interest

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Author contribution

The author read and approved the final manuscript. The author verifies that the Text, Figures, and Tables are original and that they have not been published before.

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