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Profit Maximization of Cattle Fattening Breed Based on Characteristics of Producers: An Application of Game Theory

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Abstract: The major purpose of this study was to determine the cattle fattening breed, which maximizes the net profit for the producers under risks and uncertainties based on different characteristics of producers. The monthly data of 21 bullocks consisted of 7 Holstein, 7 PiedmonxHolstain and 7 LimuzinxHolstein cross-breed cattle fattened in closed tie-stall experiment barns of Aegean Agricultural Research Institute, Izmir, Turkey were used in the study. The games were constructed based on the net profit per cattle obtained in the 5th month of fattening where the highest total profit was obtained. Maximaks, Wald, Regret, Hurwicz, Utility and Laplace Criterions of Game Theory were used. The Maximaks, Regret, Hurwics and Laplace Criterions showed that the best breed was Limuzin for the producers in terms of net profit per cattle. According, the results of Wald and Utility Criterions of Game Theory, the optimal breed was Piedmont. Holstein breed was not compatible with any criterions used in this study. Since, the highest net profit per cattle ($ 588.33) is obtained from Limuzin breed by applying Maximaks Criterion, we strongly recommend this breed for optimistic producers. However, the characteristics of producers will determine which criterion to apply to choose the best breed.

Key words: Cattle fattening, game theory, net profit

INTRODUCTION

Production variability in agricultural enterprises is one of the most serious challenges, which the producers should cope with. Two possible sources of this variability are production risks and technical inefficiency (Bokusheva and Hockman, 2006). Risks and uncertainties stemmed from market conditions (primarily market prices) are the variables, which generally the producers can not control. Therefore, the need for governmental support is evident (Lopez *et al*., 2005) and many governments including U.S. and European Union Countries have extensive support programs for producers of various plant and animal products (Zohra *et al*., 2002).

The breed, which has relatively high live weight gains and require less feed intake is considered as one of the most significant variable that affects the profitability of the cattle fattening enterprises (Coldow *et al*., 2005; Wolfova *et al*., 2004). The sustainability of cattle fattening enterprises has to do with a planning for determination the optimal breed. Since, many planning methods ignore the producer's risks and uncertainties, the game theory is an appropriate tool for planning the cattle fattening enterprises under risk and uncertainties of production and marketing conditions (Rasmusen, 2006; Herath, 2006; Camerer, 2003).

Although, many researches have been made regarding the profitability of cattle fattening farms in Turkey (Yıldırım, 2006; Eren, 2006; Sayılı, 2001), determination the breed which maximizes the profit of cattle fattening by means of game theory approach is not available, which increases the importance of this study.

The application of game theory is widespread (Holsteiner, 2003; Başaran and Bölen, 2006; Lee and Kennedy, 2007). The game theory has also been used efficiently in the filed of agricultural. The economical analysis of rice trade among the U.S. Japan and South Korea was made by means of Game Theory (Lee and Kennedy, 2007). In a research conducted in Germany, the competition among the dairy enterprises on the determination of price and reduction in prices were evaluated according to game theory approach (Müller, 1999).

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Game theory was applied to field crops such as wheat, barley, maize, chickpea, sesame, cotton and peanut in Antalya province of Turkey. To determine the highest net income under the worst conditions Wald criterion was used. The riskiest crops for the research area were reported as pistachio and cotton (Özkan and Akçaöz, 2002). The optimal selling times for some selected storable crops in Aegean region, Turkey was estimated using game theory (Miran, 1995). The best selling times for beef and milk in Turkey were determined by means of game theory (Şahin, 2008).

The major purpose of this study was to determine cattle fattening breed with highest net profit. To reach this aim, the optimal fattening period was determined under controlled conditions and the data of this period was taken into consideration.

MATERIALS AND METHODS

The animal material used in the research included 21 bullocks consisted of 7 Holstein, 7 PiedmonxHolstein and 7 LimuzinxHolstein cross-breed cattle fattened in closed tie-stall experiment barns of Aegean Agricultural Research Institute, Izmir-Turkey. The monthly data obtained from the animal material was used in the analysis of this study.

Rearing and fattening period was 10 months (10×28 = 280 days) and 6 months (195 days), respectively. Feed intakes were recorded systematically during the fattening period. The fattening period was terminated in December 1999 and the related prices were updated for the year of 2007 (Anonymous, 2007).

Net profit was calculated by subtracting the production costs from the gross production value (Kıral *et al*., 1999; Yıldırım, 2006). By comparing the monthly net profits, it was concluded that the fifth month of cattle fattening was the most profitable month. Thus, the games were constructed based on the data of this month.

The games were constructed for each breed separately and analyzed with Maximaks, Wald, Regret, Hurwicz, Utility and Laplace criterions of game theory. These criterions were accepted to represent the characteristics of producers (Miran, 2005; Şahin, 2008; Altaylı, 1996). The producers have the opportunity to choose one of the breed among the 3 breed (Holstein, Limuzin and Piedmont) as a strategy (Table 1).

It was accepted that producer had 2 strategies (Good Conditions and Bad Conditions of Production and Marketing). These strategies were constructed based on the 2 scenarios (Table 2).

While, the minimum net profit represented the improvement in production and marketing conditions, the average net profit was the reflection of deterioration in production and marketing conditions. One-way variance analysis was applied to compare the net profits of breed.

Table 1: Characteristics and strategies of producers

Strategies	Criterions	Characteristic of producers	Explanations
A1-Holstein A2-Limuzin A3- Piedmont	Maximaks	Optimistic	Production and marketing Conditions will improve. The producer takes risks
	Wald	Pessimistic	Production and marketing Conditions will deteriorate. The producer averts risks
	Regret	Minimum regret	The producer minimize probable regrets
	Hurwicz	Between optimistic-pessimistic	The producer is indecisive on being optimistic or pessimistic
	Utility	Risk Averter	The producer has not much tendency towards risks
	Laplace	Cautious	The producer evaluates the conditions with prudence

Table 2: The scenarios, strategies and characteristics of production-marketing conditions

Scenarios	Strategies	Production/marketing characteristics
1st	B1-good conditions	Improvements in production and marketing conditions High breed productivity High meat prices.
2nd	B2-bad conditions	Deterioration in production and marketing conditions Low breed productivity Low meat prices

RESULTS AND DISCUSSION

Maximaks criterion: According to Maximaks criterion, the player (the producer) chooses the best among the conditions determined at each strategy. The decision maker is optimistic about the production and marketing conditions. Maximaks criterion showed that Limuzin breed, which yielded $ 588.33 net profit per head, was the best choose. However, in the event of bad conditions, the producers should take into consideration that the net profit per cattle will decrease up to $ 272.58 (Table 3).

Wald criterion: This criterion is an approach which the pessimistic producer will prefer to apply. In light of this criterion, the decision maker prefers the highest value of bad conditions (Şahin, 2008). Piedmont breed yielded $ 298.77 net profit per head, which represent the highest value of bad conditions. This value is the quarantined highest value for producer. There is possibility of obtaining $ 449.47 net profit per head in case the production and marketing conditions improve (Table 4).

Regret criterion: Regret criterion minimizes the probable regrets for decision maker. For example, when the producer chooses the Holstein breed, his alternative cost

Table 3: Game for producer against production-marketing conditions according to maximaks criterion ($/Head)

	B_1	B_2
Breed	Good conditions*	Bad conditions*
A_1 Holstein	368.20	200.71
A_2 Limuzin	588.33	272.58
A_3 Piedmont	449.47	298.77

*: $p<0.05$

Table 4: Game for producer against production-marketing conditions according to wald criterion ($/Head)

	B_1	B_2
Breed	Good conditions	Bad conditions
A_1 Holstein	368.20	200.71
A_2 Limuzin	588.33	272.58
A_3 Piedmont	449.47	298.77

Table 5: Game for producer against production-marketing conditions according to regret criterion ($/Head)

	B_1	B_2
Breed	Good conditions	Bad conditions
A_1 Holstein	588.33-368.20 = 220.13	298.77-200.71 = 98.06
A_2 Limuzin	588.33-588.33 = 0	298.77-272.58 = 26.19
A_3 Piedmont	588.33-449.47 = 138.86	298.77-298.77 = 0

will be $ 588.33 net profit per head obtained from Limuzin, which is the best breed, provided that production-marketing conditions improve. Thus, the regret of producer will be $ 588.33-$ 368.20 = $ 220.13 net profit per head.

The regret values for each strategy of production-marketing conditions the players were determined according to both good and bad conditions and minimax criterion was applied to these values (Table 5).

Since, the lowest chosen value was 26.19, the Limuzin breed yielded $ 272.58 per head, which is the lowest regret degree point where the production could be made. In event the production and marketing conditions improve, the producer has the opportunity to obtain up to $ 588.33 net profit per head.

Hurwicz criterion: According to Huwicz criterion, the producer is between optimistic and pessimistic attitude. Each result has been weighted according to optimistic coefficient. The highest and the lowest values of each strategy has been multiplied by optimistic coefficient (α) and pessimistic coefficient ($1-\alpha$), respectively and the difference between the 2 results has been calculated. The highest calculated value was determined as the choice, which the producer will make the decision. A value for a little bit pessimistic producer was accepted as 0.4 (Sahin, 2008). The highest value was found for Limuzin breed with $ 71.78 net profit per head (Table 6). The difficulty of applying this criterion is to determine the optimistic coefficient.

Table 6: Game for producer and against production-marketing conditions according to regret criterion ($/Head)

	B_1-B_2
Breed	Good-Bad conditions
A_1 Holstein	368.20 (0.4)-200.71 (0.6) = 26.85
A_2 Limuzin	588.33 (0.4)-272.58 (0.6) = 71.78
A_3 Piedmont	449.47 (0.4)-298.77 (0.6) = 0.53

Table 7: Game for producer against production-marketing conditions according to utility criterion ($/Head)

	B_1	B_2
Breed	Good conditions	Bad conditions
A_1 Holstein	368.20-368.20 = 0	200.71-200.71 = 0
A_2 Limuzin	588.33-368.20 = 220.13	272.58-200.71 = 71.87
A_3 Piedmont	449.47-368.20 = 81.27	298.77-200.71 = 98.06

Table 8: Game for producer and production-marketing conditions according to laplace criterion ($/Head)

	B_1-B_2	
Breed	Good conditions+Bad conditions =	Weighted values
A_1 Holstein	368.20 (0.5) + 200.71 (0.5) =	284.46
A_2 Limuzin	588.33 (0.5) + 272.58 (0.5) =	430.46
A_3 Piedmont	449.47 (0.5) + 298.77 (0.5) =	374.12

Utility criterion: This criterion assumes that the producer is risk averter. To determine the utility values, the lowest value of strategies was determined and was subtracted from all results of related strategy. The highest value was found for Piedmont breed with $ 81.27 per head (Table 7).

Laplace criterion: According to Laplace criterion, when the probabilities of conditions are not known, the probabilities are accepted as equal. The probabilities of the good and bad conditions are equal. No condition has a priority to another one. Good and bad conditions were given ½ weights. The weighted value of each breed strategy was found by multiplying both of 2 conditions with 0.5 and then added together. Since, the highest weighted value was 430.46, the decision maker will choose the Limuzin breed. In case of production and marketing conditions improve the producer will obtain $ 588.33 net profit per head, while this figure will decrease up to $ 272.58 net profit per head under bad conditions (Table 8).

The risk perception of producer is essential on which criterion of game theory will be chosen as the best criterion. In light of the results obtained from the criterion of game theory, optimistic producers, those who want the least regret degree, those between optimistic and pessimistic and the prudence producers will choose the Limuzin breed while the pessimistic and risk averter producers will prefer the Piedmont breed.

Aggregate game criterion results: The highest net profit per head of $ 588.33 was reached for Limuzin breed by

Table 9: Aggregate game criterion results of producer against production-marketing conditions

Characteristics of producers	Criterion	Net profit ($/Head)	Breed to choose
Optimistic	Maximaks	588.33	Limuzin
Pessimistic	Wald	298.77	Piedmont
The Least Regret	Pismanlik	272.58	Limuzin
Between optimistic and pessimistic	Hurwicz	588.33-272.58	Limuzin
Risk Averter	Fayda	449.47	Piedmont
Prudence	Laplace	588.33-272.58	Limuzin

applying Maksimaks criterion. The second highest net profit per head was $449.47 obtained for Piedmond breed by applying the Utility Criterion. The net profit per head obtained from applying Hurwicz and Laplace criterions ranged from $ 272.58-$ 588.33 for Limuzin breed (Table 9).

The results showed that the most profitably criterion compatible with the game criterions was Limuzin breed. Holstain breed was not consistent with any criterions of game theory applied in this study. Limuzin and Piedmond breed are advisable relative to characteristics of producers.

CONCLUSION

We strongly recommend that producers should prefer Limuzin breed in light of Maximaks, Regret, Hurwicz and Laplace criterions of game theory. The producer may choose the Piedmont breed in line with Wald and Utility criterions. Since, Holstein breed was not compatible with any criterions of game theory applied in this study, the producer should not prefer this breed.

The optimistic producers, which assume the production and marketing conditions will improve and they are ready to take risk should prefer Limuzin breed with $ 588.33 net profit per head in line with Maximaks criterion.

The pessimistic producers, which assume the production and marketing conditions will deteriorate and therefore, they are reluctant to take risk, should prefer the Piedmont breed with $988.77 net profit per head taking into consideration the Wald criterion.

The characteristics of producer have the determinative effect on the net p rofit he could obtain. The higher the profit the producer could obtain the higher risk degree he will undertake. To alleviate the risk level that the producer will face, the price policy of government should be clear enough for the producers so that they could make a more efficient plan for their activities.

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