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Flexible Investment Strategies for Maximizing Returns under Spatial Variation and Uncertainty in Beef Cattle Investment Decision-Making

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Running Title: Flexible Investment Strategies for Agricultural Investment

Abstract

Designing the flexible investment strategies for maximizing returns under spatial variation and considering uncertainty in beef cattle investment decision-making are vital. Therefore, the objectives of the study were (i) to explore the real options and its values spatially for beef cattle investments in Türkiye, and (ii) to evaluate the adequacy of government support for beef cattle investment spatially. Research data were collected from randomly selected 385 beef cattle farms by using questionnaires. The valuation of real options was assessed by using Binomial Valuation, Black-Scholes Method and Monte Carlo simulation. Tornado diagram was used for exploring sensitivity of decision variables for beef cattle investment. The results of the research showed that the classical net present value (NPV) value was -200.82 thousand US $. The NPV values of the options of wait, expand and input-output change for the beef cattle investment were 102.37 thousand US $, 43.87 thousand US $, and 24.50 thousand US $, respectively. The research findings also showed that the value of real options and adequacy of government subsidies varied spatially. Based on the resuts of the sensitivity analysis, the most important variables affecting the investor's decision are carcass meat price, yield rate, capacity utilization rate and fattening feed price, respectively. The research suggests that policy makers should consider the spatial distribution of investment subsidies and policies to the specific needs of different regions to increase efficiency of investment support policy.

Keywords: Beef Cattle Investment, Valuation of Real Options, Sufficiency of Investment Subsidies, Flexible Investment Strategy.

1. Introduction

The red meat sector assumes paramount significance within the national economy owing to its critical role in human nutrition, coupled with the consequential value addition and employment generation it affords. In Türkiye, beef production, a substantial component of red meat demand, escalated from 882 thousand tons in 2014 to one million tons in 2019 (TOB,

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2020). The year 2020 witnessed a beef cattle population of 2.1 million, with 49% attributed to cultured breeds and 42% to hybrid breeds. The general profile of the farming system in Türkiye reveals a diverse landscape of beef cattle rearing practices employed by farmers. Beef farmers engage in a mix of traditional and modern rearing techniques to enhance productivity. Central Anatolia and Eastern Anatolia regions play a central role, hosting 45% of cattle breeding activities. These regions are favored for their expansive landscapes and favorable climatic conditions. The prevalence of closed barns with modern technologies in these areas emphasizes a shift toward more controlled and efficient beef farming practices. In Türkiye, the fodder crops production potential exhibits distinct regional variations influenced by diverse climatic and geographical factors. Coastal regions, such as the Aegean and Mediterranean, benefit from mild climates, enabling the cultivation of various fodder crops throughout the year. These areas are particularly suited for the production of perennial crops like alfalfa. Inland regions, such as Central Anatolia, face more pronounced seasonal variations, impacting the choice of crops. Drought-resistant varieties like clover and certain grasses are well-suited for the continental climate. Eastern Anatolia, characterized by higher elevations, has a shorter growing season but can support cool-season fodder crops. In spite of the fact that beef production potential due to agricultural areas suitable for forage crop production, red meat production has not reached the required level in Türkiye. Due to a notable increase in beef consumption surpassing the production growth rate, Türkiye consistently experiences in beef imports. Therefore, addressing the escalating demand necessitates imperative investments in new beef cattle ventures that align with the diverse and evolving landscape of farming practices in the country.

Due to it provides opportunity for steady income and the potential for capital appreciation, creating a new beef cattle business by allocating the required fixed capital investment (barn, machinery etc.) and working capital is a popular agricultural investment (Ağır, 2018; Nevondo et al., 2019). However, like any other agricultural investment, it is subject to various uncertainties, such as market volatility, disease outbreaks, and changing consumer preferences. To account for these uncertainties, investors can make use of real options, which provide the flexibility to adjust their investment strategies based on changes in market conditions. Incorporating real options and considering the spatial variation in real option values, as well as the supply-demand dynamics in the market, can provide valuable insights for making informed investment decisions in the beef cattle sector. Despite its potential advantages, however, there remains a gap in the literature regarding the practical application of real options valuation (ROV) in real-world decision-making contexts. Most previous studies have focused on farm, land and agricultural technology investment valuation or single and multi-year crops. Luong and Tauer (2006) calculated entry and exit prices for coffee producers and suggested that policy makers adjust their subsidies according to these prices. Du and Hennessy (2012) found the rental value of agricultural land using ROV and showed that it is higher than NPV. Regan et al., (2015) showed in their study in Australia that the NPV method leads to unrealistic results in the prediction of land use change under uncertainty conditions. Hauer et al., (2017) developed a normative spatial model that takes into account option values for conversion from agricultural to forest land and their different time scales. Smith (2018) used ROV to calculate input and output prices for an agricultural farm producing sugarcane. Spiegel et al., (2020) explained with ROV analysis why hazelnut plantation investment is increasing in Italy despite the fact that it is not profitable except on sloping land. However, the real options approach has been used in a limited number of studies in animal production. Purvis et al., (1995) analyzed the investment in a free-stall dairy housing with ROV and suggested subsiding producers willing to adopt the new technology. Engel and Hyde (2003) evaluated the investment of automatic milking system with NPV and ROV methods and revealed that the two methods gave significantly different results. Lien (2003) valued the investment in a Norwegian dairy farm using the stochastic method and included real options in the model. Muller (2018) analyzed the effect of corporate risk on the investment decision of dairy farms in the Netherlands with ROV. Real options and its valuation in beef cattle investment has been rarely studied. De Lamare Bastian-Pinto et al., (2015) calculated the value of the option of determining the timing of confined feeding and demonstrated the importance of correct timing. Perez et al. (2022) demonstrated the value of decision flexibilities in production processes in beef cattle farm. The number of studies where real options in beef cattle investments are determined and valued is quite limited. There has been also literature gap on the adequacy of government support for beef cattle investment. Addressing this literature gap mentioned above in the literature have motivated the current research. This study intended to answer two research questions; the first question was, " How do the presence and valuation of real options (wait, expand, change input and output) in beef cattle farming investments vary across different regions?" The second question was, "Does sufficiency of government support allocated to beef cattle investments regionally varies?" To answer the questions, the objectives of the study were (i) to explore the real options and its values regionally for beef cattle investments in Türkiye, and (ii) to evaluate the adequacy of government support for beef cattle investment regionally.

2. Material and Methods

2.1. Research area and data sources

Research area included 14 different provinces of Türkiye such as Erzurum, Kars, Diyarbakır, Şanlıurfa, Konya, Ankara, Samsun, Amasya, İzmir, Aydın, Adana, Kahramanmaraş, Balıkesir and Bursa, which are selected to represent 7 different regions of Türkiye (Fig. 1). Beef cattle farms, managers of Red Meat Producers Associations (RMPA) and expert of Ministry of Agriculture and Forestry (MoAF) were the basic data sources of the research.

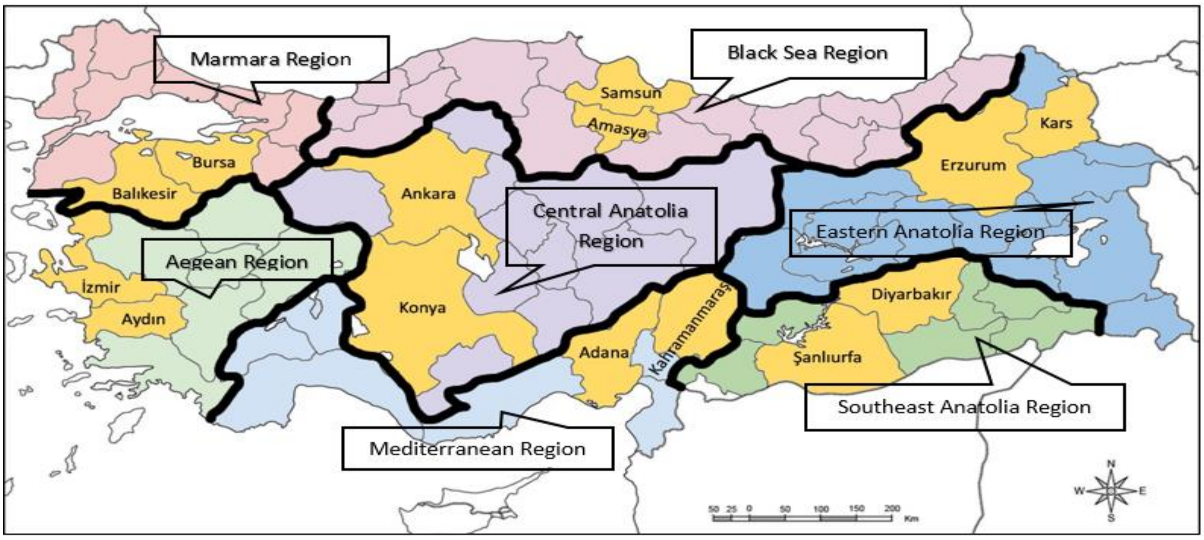

Figure 1. Research area.

The study covered beef cattle farms having 50 or more beef cattle. There are approximately 13 thousand beef farm cattle having 50 or more beef cattle in Türkiye in 2019. The provinces of Erzurum, Kars, Diyarbakır, Şanlıurfa, Konya, Ankara, Samsun, Amasya, İzmir, Aydın, Adana, Kahramanmaraş, Balıkesir and Bursa were purposively selected as a research area (Fig. 1). Each of the selected provinces constituted the 80% of the total number of beef cattle in their region, which are selected to represent 7 different regions of Türkiye.

Beef cattle farms, managers of RMPA and expert of MoAF were the basic data sources of the research. 4333 beef cattle farms having 50 or more beef cattle in the provinces of Erzurum, Kars, Diyarbakır, Şanlıurfa, Konya, Ankara, Samsun, Amasya, İzmir, Aydın, Adana, Kahramanmaraş, Balıkesir and Bursa constituted the population of the study. Sampling frame of the study was created based on the number of cattle of each beef cattle farm. Optimum sample size was calculated by following simple random sampling procedure. When calculating the optimum sample size, a confidence level of 95% (z= 1.96) was used, and the maximum allowable margin of error was 0.05. Calculated optimum sample size was 385. The sample beef cattle farms were randomly selected by using random numbers table from the sampling frame.

The distribution of the optimum sample size for Erzurum, Kars, Diyarbakır, Şanlıurfa, Konya, Ankara, Samsun, Amasya, İzmir, Aydın, Adana, Kahramanmaraş, Balıkesir and Bursa were 37, 28, 29, 20, 50, 63, 18, 17, 31, 21, 20, 11, 26 and 14, respectively. Farm level research data was collected from randomly selected 385 beef cattle farms through in November and December 2021. Due to participating the questionnaire was in volunteer base, replacement farms by 25% of the optimum sample size were created. Questionnaire was administered to replacement farm instead of beef cattle farms rejecting participating the questionnaire. Questionnaire was composed of questions regarding socio-economic characteristics of the beef farm and operator (farm size, farmland, barn size, net farm income, capacity use ratio, age, education level, experience etc.), production characteristics (carcass yield, fattening period, daily gain etc.), and information related to investment and real options. In addition, 14 managers of *RMPA* and 14 *MoAF* expert were interviewed by using semi-structured form in order to regionally determine the existence of real options such as wait, expand, changing input and output. During the interview, information was received about the farmers who conducted a feasibility study for investment in a beef cattle and applied for support in order to determine the wait option. It was also questioned whether there were any existing farms that had invested or applied for expansion. Besides, to question the feasibility of the option to change inputs and outputs, questions were asked about what types of feed farmers could supply when interviewing with managers and experts.

Time series data covered the time period of 1980 to 2021 for the prices of carcass meat, feed, barley, clover, straw, silage and labor expenses obtained from Turkish Statistical Institute (TSI), FAO and Feed Producers Association (FPA) were also used in the study Regional level price data were mainly based on the statistics collected from TSI and feed producers while some national level input price data were obtained from FAO. Time series data were used to elicit expected incremental cash flows (NCF) along the economic life of beef cattle investment. Time series data were also used for creating 10-year price forecast and standard deviations.

2.2. Valuation of Real Options

In our study, the classical investment theory was adopted as a reference analysis. This theory considers the *NPV* of the *NCF*. In the initial stage of evaluating the investment with NPV, the estimated 10-year cash flows of the beef cattle investment were calculated. The time series, representing the years 1980-2021, were deflated by using the producer price index. After testing the stationary of the time series using the Augmented Dickey-Fuller (ADF) unit root test, forecasts for the years 2022-2031 were determined by using Autoregressive Moving Average

(ARIMA) models. The economic life of the investment (n) was assumed to be 10 years. The average interest rate of 10-year government bonds for the period between January 2011 and December 2020, which was used to discount cash flows to calculate present value, was 10.80%.

The sensitivity analysis of the beef cattle investment decision to the change in investment variables was evaluated through the tornado diagram. Tornado diagram shows the effect of a change in one variable on the investment value, while the other variables are constant (Mun, 2002). In the diagram, variables are listed from most to least affecting the investment value.

Since *NPV* and similar methods used in evaluating investments are insufficient in assessing the flexibility of an investment in the face of uncertainties, *ROV* was used to explore flexible investment strategies for beef cattle investment.

When determining the options of the beef cattle investment, 13 questions were asked to operators of beef cattle farms. Individual interviews were conducted with the experts in the field and their opinions were elicited. Based on the response of the operators of beef cattle farms and expert opinions, real options for beef cattle investment were wait, expand and changing input-output. It was also assumed that there was a forage crop production to meet the feed demand that will arise by establishing new beef cattle farm and increasing the capacity of existing beef cattle farms.

Wait option is benefiting from the waiting until conditions improve instead of immediately reject investment based on the results of the classical ROV method. When market conditions are good, the option of a farm to increase its capacity to reduce costs by taking advantage of economies of scale is called an expand option. The option of changing input-output is the option for the producer to reduce costs by changing the inputs used in the production process or to change the outputs by intervening in the production process (Trigeorgis, 1996).

Binomial valuation method developed by Cox et al. (1979) was used in the valuation of the real option to wait. Binomial tree was created with the assumption that the cash flows of the investment (S) will move upwards with p probability (u) and downwards with $1\text{-}p$ probability (d) in discrete time. S in the binomial tree was the present value of *NCF*s calculated by time series analysis. The magnitudes of the u and d were calculated using the formulas below. In the equations, σ and t represented the variability and expiry date of the option, respectively (Mun, 2002).

$$u = e^{\sigma\sqrt{\Delta t}}$$

$$d = e^{-\sigma\sqrt{\Delta t}}$$

Using the calculated u and d values, the risk neutral probability (P) was calculated with the help of the formula depicted below.

$$P = \frac{e^{\sigma\sqrt{\Delta t}} - d}{u - d}$$

The following formulas were used when calculating the annual change and variability (Uzunlar and Aktan, 2006).

Annual change $v_t = ln\left(\frac{NCF_t}{NCF_{t-1}}\right)$

Variability $\sigma = \sqrt{\frac{\sum(u_t - \bar{u})^2}{(n-1)}}$

The investment cost was subtracted from the values in the last node of the binomial tree (underlying cage) created to evaluate the wait option. The value of the option was calculated with the help of the following formula, and the value at the starting point revealed the value of the wait option.

$$C = [p * S_u + (1-p) * S_d]/e^r$$

In equation, C represented the value of the wait option, S_u represented the upward initial value, S_d represented the downward initial value, and r *was* the risk-free rate of return.

When assessing the value of expand option, the increase in beef price along the 2.04 years was considered as observation time to enlarge the production scale.

Monte Carlo simulation and dynamic programming methods were used in the valuation of changing input-output options. Excel package program, and the @risk trial version software were used for financially modeling of the beef cattle investment and Monte Carlo simulation. In determining the options to change inputs and outputs in beef cattle investment, alternative rations and fattening period created based on the data collected from beef farm in different region were considered. In calculating the value of the option of using alternative feeds, total feed amounts per beef cattle were calculated for 10 different rations. 10-year price estimates and standard deviations were determined by time series analysis using the prices of fattening feed, barley, silage, maize, straw and clover used in rations from 1980 and later. The long-term prices feeds used in the ration, the estimated input prices and their standard deviations were simulated under the assumption that the producers can choose the one with the lowest cost among these rations. In addition, the assumption that farmers ensure marginal income marginal cost balance by determining the fattening period and do not reduce the *NCF* value to negative was imposed as a condition in the simulation. The variables included in the model were randomly changed 10 thousand times by using Monte Carlo simulation and the annual *NCF* was recalculated. Then, the values of the input-output options were calculated by subtracting the traditional *NCF* from recalculated *NCF*.

2.3. Method for evaluating the adequacy of government subsidies

The required support rates calculated in the study by using traditional and the *ROV* method were compared with the support rates announced by *MoAF* and Agricultural and Rural Development Support Institution (ARDSI) in order to reveal the adequacy of government subsidies for beef cattle investment. *MoAF* provides subsidy by 50% of total investment oriented to the purchase of infrastructure and machinery equipment for beef cattle farming with the limits of 0,57 million US $ to accelerate red meat production (MoAF, 2022). Simultaneously, ARDSI provides subsidy by 50-70% of total beef cattle investment based on the criteria of legal status, age and land ownership (ARDSI, 2022). The required support rate (RSR) was calculated by dividing *NPV* generated by the classical *NPV* method by the amount of investment cost at support threshold. The value of wait was included in *RSR* calculation in the study. The *RSR* for switching the positive beef cattle investment decision is calculated with the help of the equation depicted below.

RSR = (classical *NPV* + value of wait option) / investment cost at support threshold

3. Results

The sample beef cattle farm conducted their activities on 102.3 hectares of farmland, on average. The operator of beef cattle farm was 46.47 years old and had 18.66 years of cattle fattening experience. 75.8% of sample beef cattle farm was individual owner of the farm asset, while the rest was company. 42,9% of the sample beef cattle farms preferred to use barns, while that of mixed ones was 40%. The percentage of beef cattle farms benefited pasture was 22.1%, and most of them conducted their activities in the Eastern Anatolia Region.

Some characteristics of beef cattle farming by region was depicted in Table 1. The barn capacity of beef cattle farm was 357 head, on average. The beef cattle farms operating in the Central Anatolia Region had the largest barn capacity. The smallest beef cattle farms were in the Eastern Anatolia Region ($p< 0.01$).

The capacity use ratio of beef cattle farms in Türkiye was 72.5%, on average. The capacity use ratio of beef cattle farms operating in the Mediterranean, Central Anatolia and Eastern Anatolia Regions were higher than that of other beef cattle farms. The beef cattle farms in the Aegean Region have the lowest capacity use ratio ($p< 0.05$).

Table 1. Characteristics of beef cattle farms by region

	Central Anatolia Region [1]	Black Sea Region [1]	Aegean Region [1]	Marmara Region [1]	Mediterranean Region [1]	Eastern Anatolia Region [1]	Southeast Anatolia Region [1]	Türkiye
Barn size (head)***	634.42 ± 1307.52^{c}	219.14 ± 329.33^{ab}	181.13 ± 482.87^{a}	451.25 ± 1447.72^{abc}	203.23 ± 95.26^{ab}	106.69 ± 55.15^{a}	356.12 ± 262.99^{bc}	357.18 ± 896.63
Number of marketed cattle (head) ***	565.21 ± 1283.05^{c}	147.40 ± 182.75^{ab}	94.65 ± 274.49^{a}	327.53 ± 1303.03^{ab}	162.61 ± 76.29^{ab}	84.20 ± 43.77^{ab}	238.06 ± 214.07^{bc}	283.71 ± 842.79
Capacity use ratio (%)***	81.49 ± 23.44^{c}	74.86 ± 20.06 ^{bc}	54.15 ± 33.29^{a}	58,57 ± 44,16^{ab}	82.75 ± 26.20^{c}	80.73 ± 18.63^{c}	63.50 ± 20.22^{ab}	72.50 ±28.71
Fattening period (month) ***	10.76 ± 1.18^{c}	10.36 ± 1.57^{bc}	9.53 ± 1.96^{ab}	9.30 ± 2.14^{a}	10.23 ± 0.96^{bc}	9.07 ± 1.40^{a}	9.51 ± 0.74^{ab}	9.92 ±1.58
Live weight (kg/head)***	718.84 ± 107.88^{c}	709.21 ± 136.74 ^{c}	700.87 ± 82.54 ^{c}	689.50 ± 102.78 ^{c}	578.87 ± 62.47^{a}	633.59 ± 76.96 ^{b}	668.47 ± 92.68 ^{bc}	680.42 ± 105.79
Carcass weight (kg/head) ***	430.87 ± 75.42 ^{d}	415.60 ± 121.40 ^{c}	383.87 ± 57.43 ^{bc}	367.50 ± 59.89 ^{bc}	309.98 ± 37.69 ^{a}	352.40 ± 55.32 ^{b}	379.56 ± 68.35 ^{bc}	386.27 ± 83.91
Carcass yield (Dressing percentage) (%)***	59.94 ±3.21^{e}	58.60 ± 2.89^{de}	54.77 ± 2.93^{ab}	53.30 ± 2.81^{a}	53.55 ± 3.11^{a}	55.62 ± 3.57^{bc}	56.78 ± 1.74^{cd}	56.77 ±3.88
Weight gain along the fattening period (kg/head)	450.64 ± 104.47	425.16 ± 119.39	389.81± 88.90	390.25 ± 88.94	291.61 ± 46.28	339.67 ± 84.42	387.86 ± 70.87	394.30 ±103.28
Average daily gain (kg/head)***	1.40 ± 0.30^{b}	1.37 ± 0.32^{b}	1.38 ± 0.27^{b}	1.43 ± 0.31^{b}	0.95 ± 0.13^{a}	1.27 ± 0.35^{b}	1.37 ± 0.27^{b}	1.34 ±0.32

[1] Values represent the mean value and the standard error value of the relevant variable.
[2] *** states that the difference between regions in terms of the relevant variable is statistically significant at the 1% probability level.
[3] The difference between the regions expressed with different letters is statistically significant at the 5% probability level.
[4] Carcass yield was calculated by using the equation of CY = (hot carcass weight ÷ the live animal weight) × 100.

Research results also showed that average weight gain during the fattening period was 394.30 kg/head, ranging from 291.61 to 450.64 kg/head, with no significant variation observed by region ($p > 0.05$). The study also revealed that the average daily live weight gain was 1,34 kilograms per head and it spatially varied ($p < 0.05$), with the Central Anatolia region having the highest daily weight gain and the Mediterranean region having the lowest (Table 1).

3.1. Characteristics of beef cattle investment

The total cost of a 150-head beef cattle investment was 0.87 million US $. The percentage of building cost was 53.23%, while that of working capital requirement was 39.39%. Working capital requirement was 0.34 million US $, which equals daily cost multiplied by the fattening period of 9.92 months under the assumption that no cash entry during fattening period. The percentage of machinery and equipment cost in total initial beef cattle investment was 7.38%.

3.2. Valuing the Beef Cattle Investment Feasibility with Classical NPV Method

The net cash flows of a 150-head beef cattle investment elicited by using the ARIMA (2 1 1) model. ADF test results indicated that the generated time series was not stationary at the level and after taking the first difference it become stationary ($p < 0.05$). The AR and MA coefficients in the ARIMA model were statistically significant ($p < 0.05$), and the error terms are normally distributed ($p > 0.05$). *NCF* was 0.67 million US $, on average, for Türkiye. By subtracting the investment cost of 0.87 million US $ from the *NPV* of cash flows, the *NPV* of the investment is determined as -0.20 million US $. According to the research results, beef cattle investment should be rejected in all regions.

The tornado diagram for beef cattle investment is depicted in Figure 2. Sensitivity analysis results showed that the most influential variable on *NPV* of beef cattle investment was carcass price. The carcass price had the power to change the NPV of the investment between -0.67 million and +0.29 million US $, when other variables held constant. Carcass yield followed it. The other sensitive variables were capacity use ratio, feed price and initial investment, respectively.

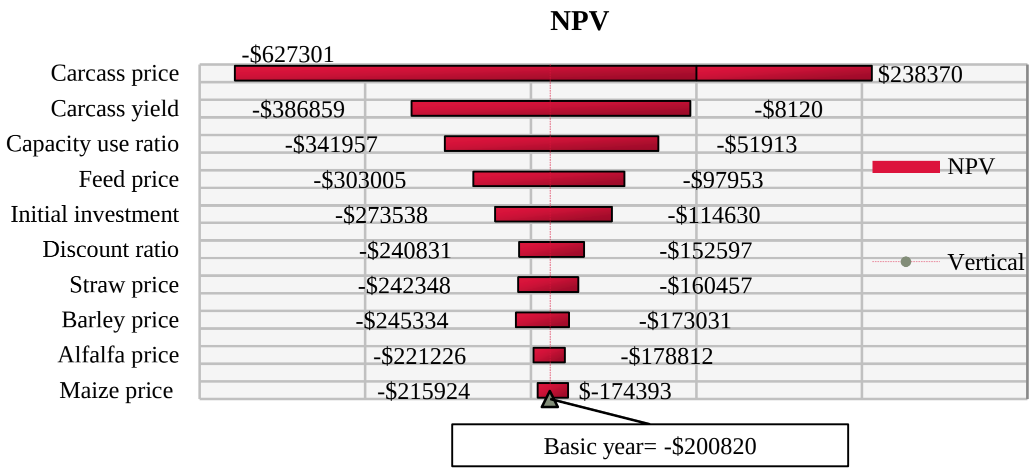

Figure 2. Results of sensitivity analysis for beef cattle investment.

3.3. The Value of Wait Option

Based on the research results, 68.8% of the operators of beef cattle farm had the opportunities for postponing the beef cattle investment, while that of operators having no wait option was 31.2%. Presence of wait option varied spatially ($p< 0.05$). Operators of beef cattle farms operating in the Central Anatolia, Black Sea and Aegean Regions have more relax for using wait option than that of operators in other regions. Also, the waiting period varied spatially ($p< 0.05$). In the Aegean and Black Sea regions, the waiting period was longer comparing with other regions. The shortest waiting period was in the Eastern Anatolia Region. Since the average time from the date of arising the idea of beef cattle investment to the implementation it in Türkiye was 1.67 years, it was used as waiting period in valuing the wait option.

Research results showed that the value of the 1.67 year wait option in Türkiye was 102.37 thousand US $. The expanded NPV of the beef cattle investment was -98.46 thousand US $. Even if the wait option was considered, the investment decision was still negative. The rejection decision was in parallel with the result of classical NPV method in 6 regions excluding the Central Anatolia Region (Table 2).

Table 2. Waiting period and the value of wait option by region.

Region [1]	Waiting period (year)		The value of wait option (thousand US $)	Expanded NPV (thousand US $)
	Mean	Standard deviation		
East Anatolia [a]	1.2419	0.56352	38.74	-259.32
Marmara [ab]	1.4975	1.35523	42.53	-280.39
South East Anatolia [ab]	1.5918	0.70470	58.69	-232.37
Mediterranean [ab]	1.6129	0.91933	11.41	-466.54
Central Anatolia [ab]	1.7214	1.29558	170.57	72.93
Black Sea [b]	2.0286	1.29446	145.69	-25.20
Aegean [b]	2.1404	1.43052	71.79	-250.20
Türkiye	1.6746	1.14933	102.37	-98.46

3.4. The Value of Expand Option

Research results revealed that 70.40% of the operators of beef cattle farm could start with a small facility and expand it if progress went well. The percentage of operators having positive attitude to benefit from expand option varied spatially ($p< 0.05$). The highest percentages were observed in the Mediterranean and Aegean Regions, while the lowest ones were in the Central Anatolia and Black Sea Regions. After establishing period, 41.3% of sample beef cattle farm increased their capacity by 200%, while 26.7% increased their capacity by 100%. The percentage of beef cattle farm having capacity increasing rate by 300% was 16.7%. Only, 15.5% of the sample beef cattle farm increased their capacity by 400%.

While half of the operators of beef cattle farm declared that they were indifference against sudden increase in meat prices, the remaining preferred to growth. 17.4% of sample beef cattle farm operator preferred to observe the continuity of the increase in beef price along the 2.04 years, then enlarged their scale. Based on the results of real option analysis, the value of the expand option by 200% for beef cattle investment with a maturity of 2 years was 43.87 thousand US $ in Türkiye.

3.5. The Value of Input-Output Changes Option

Majority of sample beef cattle farms tended to continue their activities in case of an increase in the price of the feed by implementing strategy to change. 37% of sample beef cattle farms preferred to switch alternative feeds use, while 15% of sample beef cattle farms tended to initiate the fodder crop production. However, 24% of sample beef cattle farms tended to interrupt their activities. Remaining beef cattle farms were indifference against feed price increase.

Sample beef cattle farms tended to manage output change via controlling fattening period. Since monitoring the weight gain of beef cattle and accordingly adjusting the fattening period was the vital for managing output change, 63% of sample beef cattle farms regularly monitored the weight gain of beef cattle. However, 37% of sample beef cattle farms ignored the weight gain monitoring. Research results also showed that 44% of the operators of sample beef cattle farms tended to interrupt the beef production when facing with insufficient weight gain. 40% of sample beef cattle farms preferred to inquiry root cause of insufficient weight gain.

The simulation results showed that the value of the option of changing input-output (VIOC) varied from 0.59 thousand US $ to 7.1 thousand US $ along the years. VIOC was lower in 2023 and 2024 in which the NCF were high, while VIOC was higher in 2031, 2030, 2025 and 2022 in which the NCF were low, indicating that managerial flexibility becomes more important in periods when profitability decreases. Based on the correlation analysis results, there was a negative relationship between NCF and VIOC ($r= -0.74$, $p< 0.05$). Beef cattle farm would have the opportunity to increase their annual NCF by 4.24%, on average, if they benefited the input-output change option (Table 3).

Table 3. The values of input-output change option by years (thousand US $).

Years	$NCF_{real\ option}$	$NCF_{classical}$ *	VIOC *	%
2022	101.88	96.42	5.46	5.66
2023	140.44	139.85	0.59	0.42
2024	130.15	129.51	0.64	0.49
2025	107.01	104.12	2.89	2.77
2026	103.88	98.24	5.64	5.74
2027	113.99	108.07	5.91	5.47
2028	120.61	115.25	5.36	4.65
2029	119.25	113.68	5.57	4.90
2030	115.96	109.62	6.34	5.78
2031	115.82	108.72	7.10	6.54
NPV	695.78	671.28	24.50	4.24

3.6. Sufficiency of government investment support for beef cattle farming

According to the results of classical NPV approach, beef cattle investment could be made if the investment support rate was 37.99% and above, while the reverse was the case if it was smaller than 37.99%. In the real option case, the decision for beef cattle investment was negative if the support rate was below 18.63%, while wait option was available for the support rate between 18.63% and 57.36%, resulting the investor waits for the suitable conditions. The support rate for immediate beef cattle investment must be above 57.36% (Table 4).

Table 4. Current support rate and recommended support rates.

$NPV_{Classic}$		Real option approach	
Support (%)	Decision	Support (%)	Decision
37.99 -	Reject	18.63 -	Reject
37.99 +	Accept	%18.63-%57.36 57.36 +	Wait Accept

Support rates calculated by classical NPV method by regions are depicted in Figure 3. It was clear that the 50% support rate given by MoAF was sufficient for the beef cattle investment in the Central Anatolia and Black Sea Regions, while it was not suitable for other regions. The results of spatial investment analysis showed that beef cattle investment would be rejected in the Mediterranean Region if subsidy rate of ARDSI for the beef cattle investment was 50-70%. However, beef cattle investment was feasible in the Central Anatolia and Black Sea Regions.

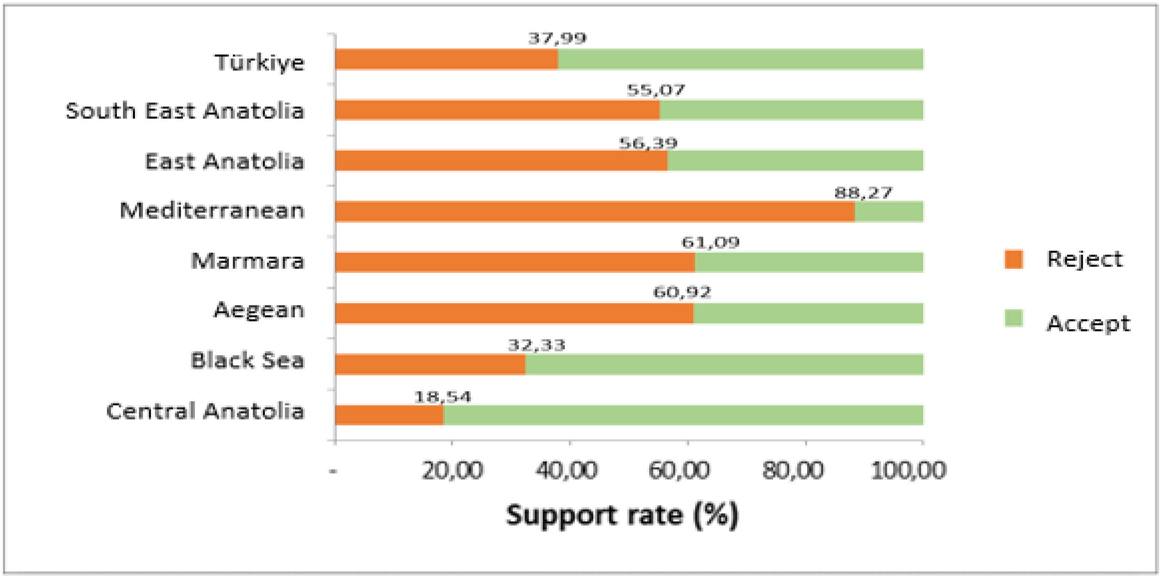

Figure 3. Subsidy rates based on classical NPV by region.

The subsidy rates calculated by considering the value of wait option were presented in Figure 4. Based on the results of the spatial real option analysis, MoAF support by 50% was still in the rejection zone for the Mediterranean and Marmara Regions, while it coincides with the wait zone in all other regions.

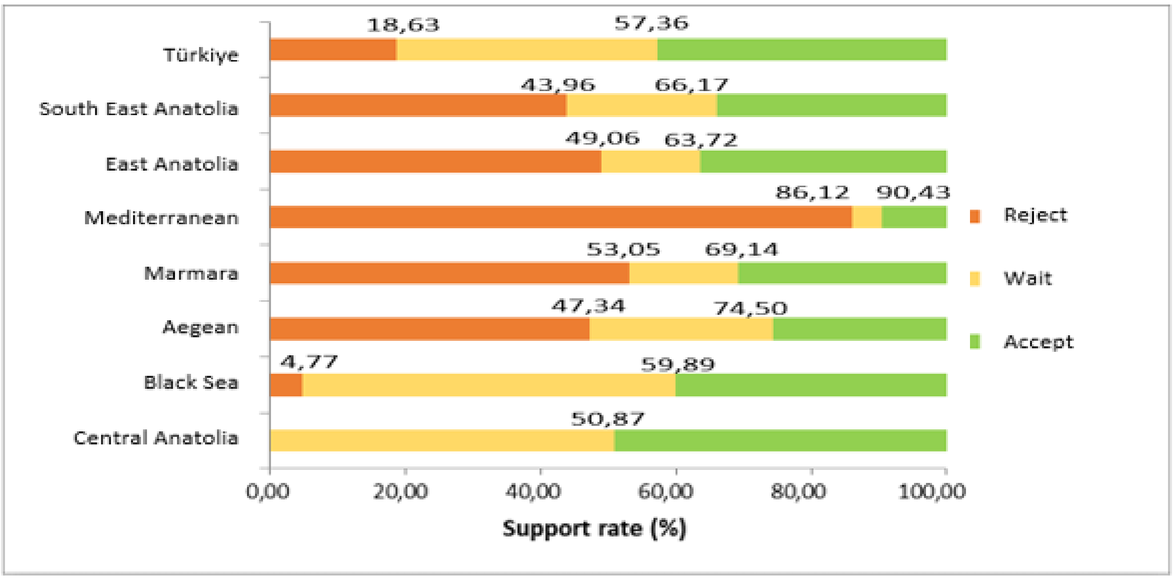

Figure 4. Subsidy rates based on real option analysis by region.

4. Discussion

The study showed that the average carcass yield in Türkiye was 56.77%, and it varied based on the region where the farm was located, ranging from 53.3% to 59.94%. The Central Anatolia Region had a higher average carcass yield compared to other regions, while the Marmara and Mediterranean regions had a lower carcass yield ($p< 0.05$) (Table 2). This finding is consistent with previous research conducted by Ceyhan and Hazneci (2010), Türkten et al. (2016), Ağır (2018), and Gezginç and Günlü (2020), in Türkiye. Up to now, previous studies have reported different carcass yields worldwide. Muir and Thomson (2008) reported a range of 51 to 60% in New Zealand. Pascoal et al. (2010) found that carcass yield ranged from 49.43 to 49.93% in Brazil. Mummed and Webb (2019) stated that carcass weight varied from 43.4 to 54.78% in Ethiopia. Fiems et al. (2003) pointed out that the average carcass yield of double-muscled Belgian blue cattle was 66.6%.

The research finding related to the fattening period accorded with the results of the previous study conducted by Gezginç and Günlü (2020). Gezginç and Günlü (2020) found that the fattening period in Holstein and Brown Swiss cattle in Türkiye ranged from 8 to 10 months. However, the shorter fattening period (8-9 months) were reported in previous studies in Türkiye (Ceyhan and Hazneci, 2010; Çelik and Sarıözkan, 2017; Ağır, 2018). In contrary, studies conducted in the United States and European countries have reported longer fattening periods than research finding. Muižniece and Kairiša, (2016) reported an average fattening period of 11 months for beef cattle in Latvia.

In beef cattle investment, carcass price was the most influential variable on NPV and it was confirmed the results of Karkacıer (1991). However, the results of previous study conducted by in Sweden had different from research result. Ahmed et al. (2020) stated that the most sensitive variables were daily weight gain, amount of feed, meat prices, silage price and grain prices, respectively.

The contemporary research findings on the regional variability of real options align with a broader body of literature that explores spatial changes in the valuation of these options. Building on this theme, Köppl-Turyna and Köppl's (2013) insightful analysis of real options in the agricultural sector revealed that variations in soil and climatic conditions contribute significantly to divergent valuation across regions. This perspective is consistent with the works of Black and Scholes (1973) and Cox et al. (1979), who laid the foundational framework for understanding financial options. Moreover, studies such as Dixit and Pindyck (1994) have emphasized the importance of incorporating real options in investment decisions, emphasizing that environmental factors, including regional variations, play a pivotal role in shaping the economic landscape.

On the other dimension, research finding related to government subsidies are consistent with the results of previous studies. The investment subsidies serve as a primary policy instrument for economically developed countries, as underscored by Skuras et al. (2006), resonates within the broader context of economic development strategies. Bernini and Pellegrini (2011) provide a perspective by highlighting the role of public subsidies in not only influencing regional investment allocation but also in catalyzing the establishment of new businesses, particularly in low-income regions. Wren's (2005) empirical evidence indicating the success of investment subsidies in creating new job opportunities reinforces the multifaceted impact of such policies on economic welfare. In the specific context of the beef cattle industry, where labor-intensive practices are integral, the job creation aspect of investment subsidies gains particular relevance. Insights from studies like van Dijk and Pellenbarg (2000) and Rodríguez-Pose and Fratesi (2004) further underscore the employment dynamics influenced by regional development policies, providing a comprehensive understanding of the intricate relationship between subsidies, regional development, and job creation. Ay (2005) analyzed the impact of investment incentives on fixed capital investments and found that there was a positive relationship between investment incentive and fixed capital investments. In the agricultural domain, the literature on the impact of investment subsidies is extensive, with studies such as Mishra and Goodwin (1997) and Demeke et al. (2009) highlighting the diverse effects of subsidies on farm-level decisions and rural development. These perspectives can be extrapolated to the beef cattle industry, suggesting that well-designed investment subsidies have the potential to not only stimulate economic activity but also foster rural development by supporting the establishment of new beef cattle farm and creating employment opportunities.

5. Conclusions

Under the light of the research findings, the study explored that real options such as wait options, expand options, and input-output change options play a significant role in the investment decision for beef cattle investment. These options had the impact on the NPV of the investment, with the wait option being highly valuable for investors who want to delay investment until market conditions improve. The expand option and the value of changing input-output were also found to be valuable for investors who want to expand their investment or switch to a different type of output if market conditions change.

Our comprehensive investigation explored significant regional variations in the values of real options within the field of beef cattle investment. This underscores the imperative for investors to meticulously weigh local market conditions and complexity of government policies when formulating their investment strategies. The observed regional disparities emphasize that a one-size-fits-all approach is untenable, demanding a nuanced and context-specific evaluation that acknowledges the unique dynamics present in each locality.

Furthermore, our scrutiny of government support for beef cattle investment revealed notable regional discrepancies in both sufficiency and effectiveness. The findings underscore the necessity of designing policies to align with the distinctive needs and challenges encountered by different regions. This regional differentiation in the landscape of real options and government support necessitates an approach that is sensitive to the specific economic, environmental, and social contexts of each region.

The implication for investors is clear that a deep understanding of the regional complexity is paramount for optimizing decision-making and maximizing the potential benefits of real options. Similarly, policy makers are urged to adopt a regionally designed approach in designing and implementing support measures for beef cattle investment. Policy makers can foster a more responsive and effective framework that aligns with the diverse conditions experienced by beef cattle producers across different regions. Ultimately, this nuanced approach serves as a strategic foundation for sustainable and economically viable beef cattle investments, enhancing the overall resilience of the industry.

Future research should focus on exploring the link between real options and environmental factors such as climate variability, land use patterns, and water availability when making beef cattle investment decision associated with regions. In addition, further research may examine the effects of technological innovation and adoption on beef cattle investment.

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