

## Evaluating Cost Structure and Economies of Scale of Beef Cattle Fattening Farms in Mashhad City

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### ABSTRACT

In recent years, the high cost of raising livestock and, consequently, the sharp increase in the price of red meat in Iran have reduced its demand, and people consume chicken meat as a substitute for it. This has reduced the production incentives and, with the bankruptcy of some beef cattle farms, the welfare of producers and consumers of this product face serious danger. To overcome this problem, understanding cost structure and reducing consumer price by reducing production costs seems necessary. Therefore, the aim of this research was to evaluate cost structure and economies of scale of beef cattle farms in Mashhad. For this purpose, the short-run Translog cost function along with input cost share equations were estimated using the iterated seemingly unrelated regression method. The data were collected in 2017 from beef cattle producers by interview using structured questionnaires. The result showed that there were increasing returns to scale for all farms. In addition, the demands for all inputs were perfectly inelastic. On the other hand, there was weak complementary and substitute relationship between inputs. According to the results of this research, the most important factor of beef production in the selected farms was feed, whose demand was inelastic and the possibility of substituting it with other inputs was very weak. Therefore, the adoption of policies by the government, including subsidies for feeding cattle and increasing the import of this input, can reduce the production cost and prevent beef prices from rising.

**Keywords:** Feeding cattle, Input demand, Iterated seemingly unrelated regression, Substitution elasticity, Translog cost function.

### INTRODUCTION

Although food consumption patterns have changed over time, meat is still an important meal component for consumers (Grunert, 2006). Meat is rich in proteins, vitamins, minerals, micronutrients and fat. It is necessary for health and is one of the main components of human eating habits (Iran Ministry of Agriculture Jihad, 2015). The main source of meat production is livestock. About 45 percent of the value added of agriculture sector in Iran is related to animal husbandry and about 3 million people are

directly involved in animal husbandry (Fatemi Amin and Mortezaei, 2013). The consumption of red meat in Iran, especially in rural areas and in low-income groups, is low compared to developed countries (Rahimi Baigi *et al.*, 2014). According to the global standard, the per capita consumption of red meat is about 30 to 45 kg (FAO, 2015), while the per capita consumption of red meat in Iran is about 12.5 kg (FAO, 2016). In recent years, the sharp increase in the price of red meat in Iran has caused a major part of the vulnerable group of the society to reduce their consumption of this

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kind of meat and to consume other kinds of meat (including chicken meat) as a substitute for it (Cheraghi and Gholipoor, 2010).

The uncertainty and price fluctuations of red meat and inputs have led to the reduction in domestic production and increase in imports (Alijani and Saboohi, 2009). According to FAO report (2015) and Iran Chamber of Commerce, Industries, Mines and Agriculture (2016), imports has always had a larger share than exports of red meat, and the trade balance of this product has been negative in the last decade. Therefore, Iran has no significant export market share of this product. Based upon the Iran Ministry of Agriculture Jihad (2007), one of the most important factors affecting the price increase of red meat is the livestock feed. An average value of 3 billion dollar livestock input is imported by Iran every year (Iran Feed Industry Association, 2017). The most important imported livestock feeds are corn, soybean meal, and barley. Corn is the first imported product of Iran and is one of the main items of livestock feed that, due to low domestic production, a significant amount of it is imported each year (Ghasemi, 2016). Given the goals of reducing imports and increasing the production of red meat in Iran at 2025 horizon, recognition of production structure and the cost structure of beef cattle farms seems necessary to allocate more investment in this sector.

In 2015, the total annual amount of red meat production in Iran was 806 thousand tons, and Khorasan Razavi Province, with 71 thousand tons, ranked the first (Iran Ministry of Agriculture Jihad, 2015). In the study area of this research, Mashhad, there are 94 beef cattle fattening farms with operation license. They raise more than 53,600 heads of cattle and calves. The total amount of beef produced in this region is about 4,000 tons (Agricultural Jihad Organization of Khorasan Razavi Province, 2017).

Beef producers often blame low farm prices and consumers blame high retail

prices (Hosseini and Shahbazi, 2010). Due to the shortage and high cost of feeds in recent years, the high cost of livestock fattening has caused some beef cattle farms in Iran to be bankrupt, which eventually led to a reduction in the welfare of producers and consumers. To overcome this problem, understanding cost structure and trying to reduce consumer price through reducing production costs seems necessary. Thus, this research aimed to examine the cost structure of red meat production in Mashhad region through the estimation of input cost share equations. Considering the significant impact of the presence or absence of economy of scale on production costs, investigation of the economy of scale was another goal of this research. In order to achieve these goals, the short-run Translog cost was used.

The study of cost structure, the economy of scale, and the estimation of substitution elasticity were first proposed by Christensen *et al.* (1973) and Berndt and Wood (1975) and further developed by Griffin and Gregory (1976). Later, several researchers used the cost function approach to analyze the structure of production in different sectors of the economy. In the following, some of the studies that have investigated the cost structure of agricultural production are mentioned.

Grisley and Gitu (1985) investigated the cost structure of Turkey production in the Mid-Atlantic region using Translog variable cost function and found that both the own-price and cross-price elasticities of input demands were inelastic. Glass and Mckillop (1989) studied the structure of Northern Ireland agriculture using a two-product, four-input Translog cost function and showed that the demand for livestock feed, fertilizer, and seeds were inelastic, whereas, the demand for labor was elastic. Guttormsen (2002) examined input substitutability in the salmon aquaculture industry of Norway by estimating a Translog cost function. The results showed that there was no substitution between inputs. Feed cost had also the largest share in total

production costs. Gervais *et al.* (2006) estimated economy of scale for three Canadian manufacturing agro-food sectors including meat, bakery, and dairy using a Translog cost function. They found that there was evidence of economies of scale in meat and bakery industries; however, there was no economy of scale in the dairy industry. Ansari and Salami (2007) studied the economy of scale in the shrimp farming industry in Iran using a Translog cost function and found that there was an increasing return to scale in this industry. Kumar *et al.* (2010) estimated the input demand functions of some Indian agricultural products. The results indicated that demand for modern inputs was more elastic. Rahmani and Ghaderzadeh (2010) estimated the cost function of poultry meat in Sanandaj city and found that feed cost had the largest share of total variable costs. Kavooosi Kalashami *et al.* (2016) evaluated production structure of warm water fish farms in Guilan Province by estimating a Translog cost function and showed that all inputs were substitutes. Tsakiridis *et al.* (2016) investigated feed substitution and economy of scale in Irish beef production systems. They estimated a short-run Translog cost with panel data by using the 3SLS method. The results indicated that all inputs were substitutes and there were economies of scale in production systems. Ozer and Top (2017) estimated demand for inputs in silkworm production of Turkey and found that the lowest price elasticity of demand was related to the mulberry leaves and the highest price elasticity was related to the transportation costs. Ejimakor *et al.* (2017) studied the production structure of agricultural sector in the southeastern United States using a Translog cost function and concluded that the demand for labor and other intermediary inputs were inelastic, while, the demand for chemicals was elastic.

Together, these studies provide important insights into the production structure of agricultural products. However, few studies have been conducted on the cost structure of red meat production and most of the

research has been carried out on dairy farming. In recent years, given the rising production costs of beef cattle fattening, an unprecedented rise in the price of red meat and, consequently, the decline in consumer demand for this product and the bankruptcy of some of these farms, the future of this industry in Iran is in danger. Therefore, it is necessary to determine the most important factors affecting beef cattle farming total costs. This could help to adopt government policies to reduce production costs of these farms. Therefore, the results of this research could be useful in this regard. Another advantage of this research is that all the variables that affect the total cost of beef cattle farming have been used. The population of this research includes all industrial beef cattle fattening farms in Mashhad. According to available statistics, there are currently 94 industrial beef cattle fattening farms in this city, of which 60 farms have been selected as samples using Cochran formula. Data was collected from the selected beef cattle producers in 2017 by conducting the interview using structured questionnaires.

## MATERIALS AND METHODS

Duality theory is an appropriate tool for estimating production functions (Diewert, 2018). According to this theory, production structure of an industry can be examined by both the production function and the cost function approaches (Shepard, 1970). Since all information about the production structure could be recovered from the cost function (Kavoi *et al.*, 2010), using the cost function instead of the production function to investigating the cost structure of an industry has several benefits. First, there is no need to impose homogeneity of degree 1 on the production function to derive equations. The cost function is homogeneous of degree 1 in input prices, such that doubling the prices will double the cost without having any effect on the input price ratio (Binswanger, 1974; Antle and



Aitah, 1983). Second, in the cost function approach, instead of input quantities that are not suitable exogenous variables at the farm level, the input prices are used as independent variables, because managers are considering exogenous input prices to make the decision to use inputs. Third, the use of production function to estimate substitution elasticity and the price elasticity of inputs require that the matrix of coefficients of production function be inverted, which leads to an increase in estimation errors. However, in the cost function approach, there is no need to invert the matrix of coefficients (Binswanger, 1974). Fourth, in estimating the production function, there is a high multicollinearity between independent variables, but this problem does not arise in the cost function (Stier, 1985).

The general form of the cost function could be shown as follows:

$$C = c(P_1, P_2, \dots, P_n, Q) \quad (1)$$

Where,  $C$  shows the total Cost,  $P_i$  is the Price of input  $i$  (assuming that there are  $n$  inputs), and  $Q$  is the production Quantity. Using the cost function to estimate the production function parameters requires considering of a particular functional form. Among the flexible functional forms used in agricultural economics studies, the Translog, the generalized quadratic, and the Generalized Leontief could be widely used (Marcin, 1991; Guttormsen, 2002).

The Translog function is the most common form of flexible functions used in production research. One of the features of this function in literature is that it does not impose any prior restrictions on substitution relationships between inputs (Christensen *et al.*, 1973). This function is most often used by the researchers because of its flexibility and variability in elasticities and returns to

scale (Sadoulet and Janvry, 1995; MacDonald *et al.*, 2000). The single-output Translog cost function could be considered as Equation (2) (Christensen and Greene, 1976; Boluk and Koc, 2010):

$$\ln C = \alpha_0 + \alpha_q \ln(Q) + \frac{1}{2} \alpha_{qq} (\ln Q)^2 + \sum_i \alpha_i \ln(P_i) + \frac{1}{2} \sum_i \sum_j \alpha_{ij} \ln(P_i) \ln(P_j) + \sum_i \alpha_{iq} \ln(P_i) \ln(Q) \quad (2)$$

Since the Translog cost function is linear homogenous relative to the input prices, input cost shares should be homogeneous of degree 1 relative to the input prices. The conditions of linear homogeneity of input prices and symmetry that guarantees a well-behaved cost function is done by applying restrictions (3) and (4) on parameters (Boluk and Koc, 2010).

$$\sum_i \alpha_i = 1 \quad ; \quad \sum_i \alpha_{iq} = 0 \quad ; \quad (3)$$

$$\sum_i \alpha_{ij} = \sum_j \alpha_{ji} = \sum_i \sum_j \alpha_{ij} = 0$$

$$\alpha_{ij} = \alpha_{ji} \quad (4)$$

In accordance with Shepard's Lemma, conditional input demand functions could be derived by partially differentiating the cost function with respect to the input prices (Banda and Verdugo, 2007):

$$S_i = \frac{\partial \ln C}{\partial \ln P_i} = \frac{P_i}{C} \frac{\partial C}{\partial P_i} = \frac{P_i X_i}{C} = \alpha_i + \sum_{j=1} \gamma_{ij} \ln P_j + \gamma_{iq} \ln Q \quad (5)$$

Where,  $S_i$  shows the cost Share of input  $i$  and  $X_i$  is the demand quantity of input  $i$ .

Given  $\sum_{i=1} P_i X_i = 1$ , so  $\sum_{i=1} S_i = 1$ . In this research, a short-run Translog cost function for beef cattle fattening farms of Mashhad is considered as Equation (6). Also, the input cost share equations are presented in the form of Equation (7):

$$\begin{aligned} \ln TC = & \beta_0 + \beta_L \ln P_L + \beta_F \ln P_F + \beta_E \ln P_E + \beta_T \ln P_T + \beta_K \ln K + \beta_Q \ln Q + \frac{1}{2} \gamma_{LL} (\ln P_L)^2 + \frac{1}{2} \gamma_{FF} (\ln P_F)^2 + \\ & \frac{1}{2} \gamma_{EE} (\ln P_E)^2 + \frac{1}{2} \gamma_{TT} (\ln P_T)^2 + \frac{1}{2} \gamma_{KK} (\ln K)^2 + \frac{1}{2} \gamma_{QQ} (\ln Q)^2 + \gamma_{LF} \ln P_L \ln P_F + \gamma_{LE} \ln P_L \ln P_E + \gamma_{LT} \ln P_L \ln P_T + \\ & \gamma_{LK} \ln P_L \ln K + \gamma_{FE} \ln P_F \ln P_E + \gamma_{FT} \ln P_F \ln P_T + \gamma_{FK} \ln P_F \ln K + \gamma_{ET} \ln P_E \ln P_T + \gamma_{EK} \ln P_E \ln K + \\ & \gamma_{TK} \ln P_T \ln K + \gamma_{QL} \ln Q \ln P_L + \gamma_{QF} \ln Q \ln P_F + \gamma_{QE} \ln Q \ln P_E + \gamma_{QT} \ln Q \ln P_T + \gamma_{QK} \ln Q \ln K \end{aligned} \quad (6)$$

$$\begin{aligned}
 S_L &= \beta_L + \gamma_{LL} \ln P_L + \gamma_{LF} \ln P_F + \gamma_{LE} \ln P_E + \gamma_{LT} \ln P_T + \gamma_{LK} \ln K + \gamma_{LQ} \ln Q \\
 S_F &= \beta_F + \gamma_{FL} \ln P_L + \gamma_{FF} \ln P_F + \gamma_{FE} \ln P_E + \gamma_{FT} \ln P_T + \gamma_{FK} \ln K + \gamma_{FQ} \ln Q \\
 S_E &= \beta_E + \gamma_{EL} \ln P_L + \gamma_{EF} \ln P_F + \gamma_{EE} \ln P_E + \gamma_{ET} \ln P_T + \gamma_{EK} \ln K + \gamma_{EQ} \ln Q \\
 S_T &= \beta_T + \gamma_{TL} \ln P_L + \gamma_{TF} \ln P_F + \gamma_{TE} \ln P_E + \gamma_{TT} \ln P_T + \gamma_{TK} \ln K + \gamma_{TQ} \ln Q
 \end{aligned}
 \tag{7}$$

Selected variables of this research include production quantity, total cost, labor price, veterinary and pharmaceutical service price, feed price, energy price, and capital as a quasi-fixed input. The description of these variables is presented in Table 1.

### Parameters Estimation Method

In Translog cost function literature, the most popular estimation method is Iterated Seemingly Unrelated Regression (ISUR) of Zellner (1963). By using this method, cost function and cost share equations could be estimated simultaneously and more efficiently than Ordinary Least Squares (OLS) method. Application of this method requires the estimation of the covariance matrix for each equation that increases the variability of the estimator sampling and

provides estimates that are numerically closer to the maximum likelihood estimator (Berndt, 1991; Greer, 2012). Since the sum of the cost shares is equal to 1, there will be only  $N-1$  linearly independent cost share equations (Banda and Verdugo, 2007). On the other hand, in each equation, the sum of the components of disturbances must be equal to 0, which means that the covariance matrix of disturbances is singular. Accordingly, one cost share equation should be deleted and its parameters through homogeneity condition need to be determined. The problem that arises is the estimated value of parameters, which may change with respect to the equation that was deleted. For this reason, iterated seemingly unrelated regression method is used, so that the estimates are not sensitive to the equation that was deleted. Also, to retain the

**Table 1.** Descriptive statistics of selected variables.

Variable	Description	Mean	Std dev	Min	Max
$Q$	Production Quantity (kg per month)	1719.071	1878/118	125	7375
$TC$	Total Cost (Toman per month)	31500000	27900000	4880167	111000000
$PF$	Feed Price (Toman per kilogram)	1010.245	129.723	512.555	1330.039
$PE$	Energy Price (Toman per head of beef)	1083.243	600.95	455	4550
$PT$	Veterinary and pharmaceutical service Price (Toman per head of beef)	21795.3	20805.24	2507.14	109417
$PL$	Labor Price (Toman-person per month)	1153167	190605.6	780000	2100000
$K$	Capital (Toman in the period of fattening)	30800000	25200000	4999995	100000000
$S_L$	Labor cost Share	0.074	0.0067		
$S_F$	Feed cost Share	0.845	0.013		
$S_E$	Energy cost Share	0.0035	0.0002		
$S_T$	Veterinary and pharmaceutical service cost Share	0.077	0.011		



condition of linear homogeneity, cost function and cost share equations should be normalized by dividing input prices into the input prices whose equation was deleted from the system (Barten, 1969; Bauer *et al.*, 1987; Greer, 2012).

### Economy of Scale

As noted by Hanoch (1975), the economy of scale should be measured along the expansion path, in which each point relates to a minimum total cost and input prices are constant. The economy of scale is defined as: the equivalent increase in total cost due to the equivalent increase in output, holding input prices fixed (Filippini, 2001). The economy of scale can be calculated from the Equation (8):

$$SCE = 1 - \frac{\partial \ln C}{\partial \ln Q} \quad (8)$$

Where,  $SCE$  shows the economy of scale

and  $\frac{\partial \ln C}{\partial \ln Q}$  is the cost elasticity. The positive value of  $SCE$  indicates that there is an increasing return to scale and negative value of it indicates that there is a decreasing return to scale (Grisley and Gitu, 1985).

Price Elasticity and Substitution Elasticity

Based on Brown and Christensen (1980), own-price and cross-price elasticities of input demands are calculated from Equations (9) and (10):

$$\varepsilon_{ii} = \frac{\partial \ln X_i}{\partial \ln P_i} = \frac{\beta_{ii} + S_i^2 - S_i}{S_i} = S_i \sigma_{ii} ; \quad (9)$$

$$\sigma_{ii} = \frac{\beta_{ii} + S_i^2 - S_i}{S_i^2} \quad \text{for } i = 1, \dots, n$$

$$\varepsilon_{ij} = \frac{\partial \ln X_i}{\partial \ln P_j} = \frac{\beta_{ij} + S_i S_j}{S_j} = S_j \sigma_{ij} ;$$

$$\sigma_{ij} = \frac{\beta_{ij} + S_i S_j}{S_i S_j} \quad \text{for } i, j = 1, \dots, n \quad \text{but } i \neq j \quad (10)$$

Where,  $\varepsilon_{ii}$  and  $\varepsilon_{ij}$  indicate own-price and cross-price elasticities and  $\beta_{ii}$  and  $\beta_{ij}$  are parameters.  $S_i$  and  $S_j$  are the cost Share of inputs  $i$  and  $j$ , which are computed as the means of the independent variables.  $\sigma_{ij}$  and  $\sigma_{ii}$  are also the Allen-Uzawa partial elasticities of substitution (Grisley and Gitu, 1985). Allen-Uzawa elasticities evaluate the change in demand quantity of each input relative to a change in other input prices, which is weighted by the cost share of the input whose price has changed (Magnani and Prentice, 2006), such that whatever the cost share of the input for which price has changed is higher, other inputs are a better substitute or complement to it.

### RESULTS AND DISCUSSION

The statistical descriptions of selected variables are presented in Table 1. This table shows that the monthly average beef production of fattening farms is about 1,719 kg. Also, feed with 84.5% of total costs has the largest cost share among the production inputs. This finding supports the previous research conducted by Guttormsen (2002) and Rahmani and Ghaderzadeh (2010). This result indicates the high importance of this input in beef production. The lowest cost share (0.35%) is related to the energy. It should be noted that the price of feed (PF) is derived from the weighted average price of corn, straw, alfalfa, and concentrate inputs. Also, the Price of Energy (PE) is derived from the weighted average price of fuel and electricity inputs.

The Translog cost function along with input cost share equations was estimated by imposing the constraints of symmetry and homogeneity using Stata 14 software (For more information about estimating cost function in Stata, see Kumbhakar *et al.* (2015)). For this purpose, cost function and cost share equations were normalized by

dividing the input prices into the energy price that has the lowest cost share and cost share equation of this input was deleted from the system. After estimating the model, the coefficients of the energy input were calculated through homogeneity condition. The results are presented in Table 2. These results show that the coefficient of determination ( $R^2$ ) of the cost function is 0.91, which means 91 percent of the variation in production cost of beef cattle fattening farms could be explained by the variation in variables of labor price, feed price, energy price, veterinary and pharmaceutical service price, and capital. The coefficient of determination for labor cost share, feed cost share, and veterinary and pharmaceutical service cost share

equations are 0.65, 0.40, and 0.61, respectively. Glass and Mckillop (1989) have also argued that the Translog models yield relatively poor fits for the cost share equations. The coefficients of the cost function do not have an important economic interpretation, but they are used in estimating the price elasticity of input demands and elasticities of input substitution. Before estimating the elasticities, the results of some goodness-of-fit tests are discussed in the followings.

In order to test the linear homogeneity, once input cost shares were estimated using ordinary least square regression, without imposing any constraints on parameters and, again, these equations were estimated by imposing homogeneity constraint on

**Table 2.** Translog cost function and cost share equations (ISUR method).

Parameter	Coefficient	t-Statistic	Parameter	Coefficient	t-Statistic
$\beta_0$	21.545	1.59	$\gamma_{LT}$	-0.00035	-0.10
$\beta_L$	**0.306	2.48	$\gamma_{LE}$	***-0.0022	-2.93
$\beta_F$	***0.901	3.41	$\gamma_{LK}$	** -0.019	-2.35
$\beta_T$	-0.223	-1.22	$\gamma_{LQ}$	***-0.032	-4.16
$\beta_E$	**0.015	2.23	$\gamma_{FT}$	***-0.068	-8.51
$\beta_K$	-0.492	-0.25	$\gamma_{FE}$	-0.0006	-0.78
$\beta_Q$	***-3.926	-3.04	$\gamma_{FK}$	0.012	0.56
$\gamma_{LL}$	***0.046	3.82	$\gamma_{FQ}$	*0.033	1.70
$\gamma_{FF}$	***0.112	7.18	$\gamma_{TE}$	0.0002	0.87
$\gamma_{TT}$	***0.068	9.63	$\gamma_{TK}$	0.007	0.47
$\gamma_{EE}$	***0.0026	5.95	$\gamma_{TQ}$	-0.00095	-0.07
$\gamma_{KK}$	-0.083	-0.55	$\gamma_{EK}$	0.00037	0.8
$\gamma_{QQ}$	-0.177	-1.41	$\gamma_{EQ}$	-0.0004	-1.04
$\gamma_{LF}$	***-0.043	-3.50	$\gamma_{KQ}$	***0.347	2.92
Cost function	$R^2= 0.91$				
$S_L$	$R^2= 0.65$				
$S_F$	$R^2= 0.40$				
$S_T$	$R^2= 0.61$				

\* \*\* and \*\*\*: Show that the coefficients are statistically significant at 10, 5 and 1 percent levels.



parameters. Then, these restrictions were tested by the Wald test. The null hypothesis of this test is the homogeneity of the cost function relative to the input prices. Table 3 shows that the null hypotheses of homogeneity are confirmed in all equations at 5% significance level.

To test autocorrelation in cost function and input cost shares, we used Durbin-Watson, Harvey LM, and overall system autocorrelation tests (For more information about these tests, see Griffiths *et al.* (1985)). The null hypothesis of these tests is that there is no autocorrelation. As can be seen from the Table 4, based upon Harvey LM and Durbin-Watson tests, there is no autocorrelation in cost function and cost share equations. Also, based upon Harvey overall system LM and Guilkey overall system LM tests, there is no overall autocorrelation in the system.

In order to test heteroscedasticity in equations used, Engle's ARCH LM and Hall-Pagan LM tests and Jarqu-Bera test were applied to test normality [for more information about these tests, see Shehata (2011)]. The results of Table 5 indicate that the null hypothesis of homoscedasticity is confirmed for all equations at a 5% significance level. Also, the results of the Jarque-Bera test shows that the null hypothesis of normality of disturbances is

confirmed for all equations at 5% significance level.

After estimating the cost function and carrying out the goodness-of-fit tests, the cost elasticity and economy of scale were calculated. The results are reported in Table 6. The average value of the cost elasticity is 0.465, which indicates that with the increase of a unit of production quantity, the total cost will increase only by 0.465. The economies of scale for all observations have been positive and the average of these values is equal to 0.535, which is significantly different from zero. It means that there are economies of scale for all selected beef cattle fattening farms. In other words, all of these farms benefit an increasing return to scale, and as production quantity increases, costs will decrease. This finding is consistent with that of Grisley and Gitu (1985), Ansari and Salami (2007), and Tsakiridis *et al.* (2016). The results of the estimating own-price and cross-price elasticities of demands are reported in Table 7. The table illustrates that the value of all elasticities is less than 1, which indicates that the demand for all inputs is inelastic. Therefore, a change in input price has a relatively small effect on the quantity of the input demand. These results match those observed in Grisley and Gitu (1985), Rahmani and Ghaderzadeh (2010),

**Table 3.** Results of the Wald test for homogeneity.

Equation	Statistic Wald	Probability
$S_L$	0.769	0.46
$S_F$	1.39	0.24
$S_E$	0.522	0.47
$S_T$	2.60	0.09

**Table 4.** Results of the Autocorrelation Tests.

Equation	Durbin-Watson statistic	Harvey LM statistic	Harvey LM Probability
Cost function	2.06	0.126	0.72
$S_L$	1.88	0.195	0.65
$S_F$	2.06	0.099	0.75
$S_E$	1.94	0.024	0.87
$S_T$	2.09	0.195	0.65
Harvey overall system LM statistic	0.446 (0.97) <sup>a</sup>		
Guilkey overall system LM statistic	12.40 (0.71) <sup>a</sup>		



**Table 5.** Results of the Heteroscedasticity and Normality tests.

Equation	Heteroscedasticity tests				Normality test	
	Engle's LM statistic	ARCH Probability	Hall-Pagan LM statistic	LM Probability	JB statistic	Probability
Cost function	0.193	0.65	0.058	0.80	3.63	0.163
$S_L$	0.0017	0.96	0.0013	0.97	1.32	0.518
$S_F$	0.110	0.73	1.10	0.29	2.63	0.268
$S_E$	0.0009	0.97	0.35	0.55	2.52	0.283
$S_T$	0.156	0.69	2.66	0.102	2.96	0.22

**Table 6.** Estimation of cost elasticity and economy of scale.

	Mean	Std dev
Cost elasticity	0.465	0.189
Economy of scale	0.535	0.189

**Table 7.** Estimation of Own and cross price elasticities of input demands.<sup>a</sup>

Input	Labor	Feed	Energy	Veterinary
Labor	-0.304* (0.163)	0.263 (0.162)	-0.026*** (0.009)	0.072* (0.04)
Feed	0.023** (0.01)	-0.022** (0.01)	0.0023*** (0.0008)	-0.0034 (0.009)
Energy	-0.0554*** (0.2)	0.676*** (0.2)	-0.025 (0.114)	0.134** (0.05)
Veterinary	0.07 (0.042)	-0.037 (0.103)	0.006** (0.0025)	-0.051 (0.09)

<sup>a</sup> The numbers in the parenthesis represent the standard error.

Tsakiridis *et al.* (2016), and Zhang and Alston (2018).

Price elasticity of demand for all inputs has the correct and expected negative sign, which suggests that with the increase in the prices, the demand for them will decrease. Own-price elasticity of feed demand is significant at 5% level and own-price elasticity of labor demand is significant at 10% level, while the price elasticities of energy and veterinary and pharmaceutical service is not significant. Also, the results show that the demand for feed is perfectly inelastic, indicating a small variation in the quantity of demand relative to a variation in the price of this input. Therefore, feed is the most important input of beef production. The results of cross-price elasticities imply that labor and energy inputs are complementary inputs, suggesting that an increase in labor price will decrease the use

of energy and vice versa. It is due to the fact that labor and machinery are used together and machinery consumes fuel and electricity. This result supports the earlier research by Nozari *et al.* (2013), Kanaani and Ghaderzadeh (2016), and Zhang and Alston (2018). On the other hand, labor and veterinary and pharmaceutical service are substitute inputs, which means that an increase in veterinary and pharmaceutical service price will increase the labor demand in order to clean livestock environment to protect them from illnesses. Also, there is a substitution relationship between feed and labor; since the use of more labor reduces the loss of feed. These results corroborate the findings of Ahmad *et al.* (1993) and Shahbazi (2016). In addition, feed and energy are substitutes. Moreover, energy and veterinary and pharmaceutical service are substitute inputs. Therefore, with the rising



veterinary and pharmaceutical service price, the producer uses more machinery to keep clean the livestock environment. This finding is in line with the results of the study of Nozari *et al.* (2013). It should be noted that there is weak substitute or complementary relationship between inputs because all of the cross-price elasticities are less than 1. Hence, it can be concluded that a change in the price of an input would not remarkably change the demand for substitute or complement of it.

The results of estimating Allen-Uzawa substitution elasticities are reported in Table 8. These results are consistent with the estimated price elasticities of input demands. Table 8 shows that there is a significant complementary relationship between labor and energy. This result is consistent with Nozari *et al.* (2013) finding. In addition, there is a significant substitute relationship between feed and energy and between energy and veterinary and pharmaceutical service. These results are similar to those reported by Ollinger *et al.* (2000). Other Allen-Uzawa elasticities were not statistically significant.

## CONCLUSIONS

Understanding the input demand and cost structure in beef cattle industry is essential for evaluating the impacts of change in government policies such as support programs. The price elasticity of demand for inputs is an important parameter in quantifying the effects of these programs.

The empirical results of this study showed that there were increasing returns to scale for all selected farms. That means significant cost reduction could be achieved with increasing output level. Therefore, the managers of these fattening farms can increase profitability by increasing the scale of the farms and production quantity. The major constraint for beef cattle producers to increase scale of the farms is shortage of capital. Accordingly, facilitating access to finance for beef cattle producers by giving bank loans with low interest rates could be helpful to expand their scale of production. The results of the estimated elasticities indicated that there were weak complementary or substitute relationship between inputs, which means that it is not easy to substitute or complement among inputs. According to the results of this research, the most important factor of beef production in the selected farms was feed, for which the demand is inelastic and the possibility of substituting it with other inputs is also very weak. Therefore, an increase in the price of this input can directly affect the welfare of beef producers and consumers. Thus, the adoption of policies by the government, including subsidies for feeding cattle and increasing the import of this input in an effort to make livestock feeds affordable for producers can reduce the production cost and prevent beef prices from rising. Furthermore, considering that the largest share in total production costs is related to feed cost, providing training courses for beef cattle producers to inform them about the optimal use of feed can be

**Table 8.** Estimation of Allen-Uzawa substitution elasticities of inputs.<sup>a</sup>

Input	Labor	Feed	Energy	Veterinary
Labor	-4.1* (2.2)	0.311 (0.191)	-7.42*** (2.7)	0.935 (0.579)
Feed	symmetry	-0.026 (0.021)	0.8*** (0.23)	-0.043 (0.122)
Energy	symmetry	symmetry	-71.4* (36.7)	1.74** (0.742)
Veterinary	symmetry	symmetry	symmetry	-0.662 (1.18)

<sup>a</sup> The numbers in the parenthesis represent the standard error.

effective in reducing production costs.

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## ارزیابی ساختار هزینه و صرفه‌های مقیاس واحدهای پروراندی گوساله گوشتی در

شهر مشهد

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### چکیده

در سال‌های اخیر هزینه‌های بالای پرورش دام و به تبع آن، افزایش شدید قیمت گوشت قرمز در ایران موجب کاهش تقاضای این محصول گردیده است و مصرف کنندگان به مصرف گوشت مرغ به عنوان جایگزینی برای آن روی آورده‌اند. این امر موجب کاهش انگیزه تولید شده و با تعطیلی برخی واحدهای پروراندی دام، رفاه تولید کنندگان و مصرف کنندگان این محصول با خطر جدی مواجه شده است. برای رفع این مشکل، شناخت ساختار هزینه و تلاش جهت کاهش قیمت تمام شده این محصول از طریق کاهش هزینه‌های تولید ضروری به نظر می‌رسد. از این رو، هدف مطالعه حاضر، ارزیابی ساختار هزینه و صرفه‌های مقیاس واحدهای پروراندی گوساله گوشتی در شهر مشهد می‌باشد. برای این منظور تابع هزینه کوتاه مدت ترانسلوگ به همراه توابع سهم هزینه نهاده‌های تولید با استفاده از روش رگرسیون‌های به ظاهر نامرتب تکراری برآورد شده‌اند. داده‌های مورد استفاده در این مطالعه به صورت پیمایشی و از



طریق مصاحبه حضوری با مدیران واحدهای پرواربندی گوساله گوشتی شهر مشهد با استفاده از پرسشنامه ساختار یافته در سال ۱۳۹۶ گردآوری شده است. نتایج نشان دهنده وجود بازدهی صعودی نسبت به مقیاس برای تمامی واحدها بوده است. هم‌چنین تقاضای نهاده‌ها نسبت به تغییرات قیمت آن‌ها کاملاً بی‌کشش می‌باشد. از سوی دیگر رابطه مکملی و جانشینی بسیار ضعیفی بین نهاده‌های تولید برقرار می‌باشد. بر اساس نتایج این مطالعه، مهم‌ترین عامل تعیین‌کننده تولید گوشت در واحدهای مورد بررسی نهاده خوراک دام بوده است که تقاضای آن کشش‌ناپذیر بوده و امکان جانشینی آن با سایر نهاده‌ها نیز بسیار اندک می‌باشد. بنابراین اتخاذ سیاست‌هایی از سوی دولت از جمله پرداخت یارانه خوراک دام به تولیدکنندگان این محصول و افزایش واردات این نهاده می‌تواند باعث کاهش هزینه‌های پرورش دام شده و از افزایش قیمت گوشت جلوگیری کند.