

Farm-Level Feed Demand in Turkey

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Abstract: Using farm-level survey data from Turkey, this study provides estimates of the price responsiveness of feed demand beef, dairy, and sheep producers. In addition, the impact of feed quality on animal yields is assessed in the Turkish dairy cattle sector.

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Introduction

In recent years, Turkish livestock supply has struggled to keep pace with the current growth in demand. This is particularly true in the red meat sector. Both cattle and sheep inventories have declined significantly since early 1980s; however, average slaughter weights and milk yields have increased over the same period. According to the Turkish Ministry of Agriculture and Rural Affairs (MARA, 1994), the breed composition and feeding practices are two important factors affecting yield growth in Turkey. The supply of feed and nutrients for the livestock industry is a major limitation for continued productivity and production increases. MARA estimates that Turkey's domestic supply of protein feeds in 1991 was 1,965 thousand metric tons (tmt), but demand for protein feed in that same year was 2,597 tmt. Without significant increases in the production of foodstuffs, the gap between the supply and demand for protein feeds and other nutrients will widen rapidly as livestock numbers and meat production increase. Ultimately Turkey may have to rely more heavily on imported meats and feeds (MARA, 1994) or suffer a reduction in productivity growth as a consequence of high feed prices and shortages of quality feeds.

Turkey's future demand for feed grains will be determined by production increases and the composition of feed rations. The nutritional value and relative price of each feed influence the feed mix. Feed grains and oilseed meals provide energy and protein in a compact form; consequently, their unit price is significantly higher than less nutritious fodders and forages. However, the greater nutritional density of feed grains enables animals to increase their daily protein and energy intake, raising productivity and feed efficiency. The objective of this study is to increase our understanding of Turkish feed demand by providing estimates of the price

responsiveness of feed demand on beef, dairy, and sheep farms in Turkey. In addition, we seek empirical evidence that feed input quality increases feed efficiency and animal productivity.

Methodology

We choose to represent the technology in each type of livestock production in Turkey by a separable cost function. The advantage of assuming separability is that it allows us to analyze input demands in the Turkish livestock sector as a two-stage process, reducing the data demands of the analysis. In the first stage, the unit cost of each aggregate input, composed of several inputs, is minimized. In the second stage, the aggregate inputs are combined in a cost minimizing fashion to obtain the desired output level. Consequently, separability allows us to focus on the first-stage optimization process for an input aggregate, such as feeds, independent of other input aggregates.

More formally, if y is the output of a particular livestock product, \mathbf{x} the vector of feed inputs, \mathbf{w} the vector of prices for these feed inputs, \mathbf{z} the vector of all other inputs (labor, machinery, land, etc.), and \mathbf{r} the vector of prices of these other inputs, we assume that the cost function, $c(y, r, w)$, has the following strongly separable form.

$$(1) \quad c(r, w, y) = c^1(y, r) + c^2(y, w)$$

The cost function in equation (1) possesses the standard properties of a cost function. It is real-valued, non-negative, non-decreasing in input prices and output, and linearly homogeneous and concave in the input prices (Diewert, 1982). In addition, the function $c(\cdot)$ is linear homogeneous in the sub-cost functions $c^i(\cdot)$, and the sub-cost functions themselves possess the standard properties of a cost function outlined above (Chambers, 1988).

Separability implies that the ratio of two inputs in the same group is independent of changes in the prices of inputs outside the group. Consequently, the derived-demand elasticities

must be equal for inputs within a group with respect to changes in prices of inputs in other groups. Substitution relationships among inputs within a group are not restricted by the separability assumption.

In the existing empirical literature, studies of derived demands, including feed demand, frequently use the transcendental logarithmic (translog), normalized quadratic, or Generalized Leontief (GL) functional forms to represent the cost function (Berndt and Wood, 1975; Binswanger 1974; Kako, 1978; Lopez, 1980; Ray, 1982; Surry and Moschini 1984; Higgins, 1986; Mergos and Yotopoulos, 1988; Huang, 1991; and Laure et al., 1996). All three of these specifications are flexible functions that can be interpreted as a second order approximation to an arbitrary twice-differentiable cost function.

For comparability, we follow previous authors and select the translog specification shown in equation (2) to approximate the sub-cost function $c^2(y, w)$.

$$(2) \quad \ln(c^2(y, w)) = \alpha_0 + \sum_i \alpha_i \ln(w_i) + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln(w_i) \ln(w_j) \\ + \beta_0 \ln(y) + \sum_i \beta_i \ln(y) \ln(w_i) + \sum_i \sum_k \delta_{ik} R_k \ln(w_i)$$

The variables in equation (2) are defined above except R_k , which are dummy variables for the eastern and western regions of Turkey. Applying Shephard's lemma to equation (2), we can obtain an expression for the demand for feed input i . This expression can be further manipulated to arrive at the share of total feed costs attributed to feed i , s_i , shown in (3).

$$(3) \quad s_i = \alpha_i + \sum_j \gamma_{ij} \ln(w_j) + \beta_i \ln(y) + \sum_k \delta_{ik} R_k$$

The symmetry, homogeneity, and adding-up properties of demand imply the following parameter restrictions.

$$(4) \quad \sum_i \alpha_i = 1; \gamma_{ij} = \gamma_{ji}; \text{ and } \sum_i \gamma_{ij} = \sum_i \beta_i = \sum_i \delta_{ik} = 0$$

Price responsiveness of feed demand is summarized by own-price and cross-price elasticities that can be calculated from equation (3) using the following formulae.

$$(5) \quad \varepsilon_{ii} = \gamma_{ii} / s_i + s_i - 1$$

$$(6) \quad \varepsilon_{ij} = \gamma_{ij} / s_i + s_j$$

Input substitution is measured by the Morishima elasticity of substitution (MES). Chambers (1988) derives MES (σ_{ij}^M) as follows.

$$(7) \quad \sigma_{ij}^M = \varepsilon_{ij} - \varepsilon_{jj}$$

The MES measures the percentage change in the ratio of a pair of factors with respect to a change in the ratio of their respective prices. Consequently, the MES provides comparative-static information about relative factor shares as factor prices change. If the MES is greater (less) than zero, then the relative share of i^{th} factor increases (decreases) as the price of the j^{th} factor rises. Two inputs are Morishima substitutes if σ_{ij}^M is greater than zero (Blackorby and Russell 1989).

Data and Estimation

The authors obtained permission from the Turkish Agricultural Economics Research Institute (AERI) to use in this study their production and cost data collected from cattle and sheep farmers across Turkey in 1998. The data set includes data from 150 beef cattle farms, 150 sheep fattening operations, 300 dairy cattle farms, and 295 sheep and goat dairy farms. The survey collected information about the quantities consumed and prices of 17 feed items, as well as other production and cost data. We aggregated the feeds into four major feed categories for cattle and dairy sectors: formula feed, forages, byproduct and meals (BY-M), and grains. Producers raising sheep and goats for slaughter in Turkey use less byproduct feeds than cattle and dairy producers, so it was necessary to combine the byproducts and meal category with the

grains (BY-M-G). The data is not suitable for computing a Divisia index, so the price indices for the feed aggregates were computed as a weighted average of reported feed prices using the sample average expenditure shares as weights.

A system of share equations based on equation (3) and subject to the restrictions in (4) was estimated using an iterative version of Zellner's seemingly unrelated regressions (SUR) technique. Homogeneity was maintained by normalizing all feed price indices by the grain price index or the forage price index. One of the cost share equations was dropped from the system to avoid singularity of the error covariance matrix.

Empirical Results

Table 1 provides the estimates of equation (5) for fed cattle and dairy cattle producers. Formula feed and forage equations fit reasonably well in the fed cattle system, with two of the three price terms significant at the 1 percent level. Estimated coefficients in byproduct and oilseed meal equation are not significant at the 5 percent level. Similar results are obtained for the dairy cattle system. Monotonicity and concavity tests revealed that violations occurred in less than 5 percent of the observations in both systems.

Table 2 displays the price elasticities and Morishima input substitution elasticities evaluated at the sample mean. Despite the relatively poor fit of the BY-M equation, the demand elasticity matrices for both the beef and dairy cattle sectors fall in the range of reasonable estimates. The own-price elasticity of formula feed demand is the most inelastic for both beef and dairy producers. This is not surprising because formula feeds contain the highest levels and greatest balance of protein and energy feed. Turkish cattle producers rely on formula feeds to provide a substantial portion of the animal's daily nutritional requirements, supplementing formula feeds with less expensive grain, oilseed meals, and by-product feeds.

Table 1. Parameter Estimates of Feed Cost Share Equations for Fed Cattle and Dairy Cow

Independent Variable	Fed Cattle				Dairy Cow			
	Dependent Cost Share							
	Formula Feed	Forage	Byprod and Meals.	Grain	Formula Feed	Forage	Byprod and Meals	Grain
Constant	0.380 (2.5)	0.391 (4.5)	0.115 (1.0)	0.114	-0.345 (-2.2)	0.700 (4.5)	0.058 (0.5)	0.587
Ln(Quantity)	-0.030 (-2.1)	0.002 (0.3)	0.014 (1.2)	0.014	0.056 (3.7)	-0.028 (-1.8)	0.012 (1.1)	0.040
Ln (FFeed / Grain Price)	0.221 (3.9)	-0.141 (-4.6)	-0.032 (-1.5)	-0.048	0.080 (2.7)	-0.051 (-2.3)	-0.007 (-0.69)	0.022
Ln (Forage / Grain Price)	-0.141 (-4.6)	0.155 (6.0)	-0.014 (-1.1)	0.000	-0.051 (-2.3)	0.072 (3.1)	-0.008 (-0.95)	0.013
Ln (By-Om / Grain Price)	-0.032 (-1.5)	-0.014 (-1.1)	-0.020 (-1.1)	0.066	-0.007 (-0.7)	-0.008 (-0.9)	0.033 (4.5)*	0.018
R ²	0.20	0.24	0.06		0.13	0.09	0.15	
Average Value	0.40	0.17	0.25	0.18	0.35	0.31	0.15	0.19
Average Predicted	0.40	0.17	0.25	0.17	0.35	0.31	0.15	0.19
Minimum Predicted	0.24	0.05	0.07	-0.05	0.21	0.22	0.03	-0.03

Note: t-statistics are in parentheses. Bold denotes significance at the 5 percent level and italics denotes significance at the 10 percent level

Forages account for 27 percent of beef cattle rations and 55 percent of dairy cattle rations.

Forages are the most important source of crude fiber in cattle diets, but they can also contain substantial amounts of protein and energy. In beef cattle rations, forages substitute most frequently for by-products, oilseed meals, and grains. Dairy producers feed significantly more forages and less formula feed than beef producers, and the substitution between forages and formula feeds is greater in the dairy sector.

Table 2. Price and Substitution Elasticity Tables

	Fed Cattle				Dairy Cow			
	Price Elasticities							
	Formula Feed	Forage	Byprod-Meal	Grain	Formula Feed	Forage	Byprod-Meal	Grain
Formula Feed	-0.38	-0.18	0.18	0.05	-0.57	0.17	0.13	0.12
Forage	-0.40	-0.67	-0.18	0.17	0.19	-0.62	0.12	0.15
Byprod-Meal	0.27	0.12	-0.76	0.42	0.31	0.26	-0.82	0.07
Grain	0.11	0.18	0.66	-0.85	0.23	0.25	0.06	-0.76
	Morishima Substitution Elasticities							
	Formula Feed	Forage	Byprod-Meal	Grain	Formula Feed	Forage	Byprod-Meal	Grain
Formula Feed		0.20	0.55	0.42		0.74	0.70	0.69
Forage	0.27		0.85	0.83	0.80		0.74	0.76
Byprod-Meal	1.04	0.89		1.19	1.12	1.07		0.89
Grain	0.96	1.03	1.51		0.99	1.00	0.82	

Table 3 displays the estimation results for the fed sheep and dairy sheep sectors. The formula feed and the BP-M-G share equations were estimated. The equations in the fed sheep system did not perform as well as in the cattle sector; however, all but one price term was significant at the 10 percent level. The estimated equations fit much better in the dairy sheep sector. Three out of four price coefficients were significant at the 5 percent level. The coefficient on the quantity variable in the formula feed equation is insignificant and has the wrong sign. The equations in both sheep systems satisfy the monotonicity and concavity properties for all observations.

Table 4 shows the price and substitution elasticities for the sheep sector. The own-price demand elasticities in both the fed sheep and dairy sheep sectors are inelastic, slightly smaller than in the cattle sector. In the fed sheep sector, demand for forages is the most responsive to

Table 3. Parameter Estimates of Feed Cost Share Equations for Fed Sheep and Dairy Sheep Sectors

Independent Variable	Fed Sheep			Dairy Sheep		
	Dependent Cost Share					
	Formula Feed	Forage	Byprod., Meal, & Grain	Formula Feed	Forage	Byprod., Meal, & Grain
Constant	0.250 (1.6)	0.378	0.372 (3.0)	-0.019 (-0.1)	0.602	0.417 (2.0)
Ln (Quantity)	0.024 (1.3)	-0.026	0.002 (0.2)	-0.003 (-0.2)	0.007	-0.004 (-0.2)
Ln (Ffeed / Forage Price)	0.027 (0.7)	-0.019	-0.046 (-1.9)	0.092 (3.4)	-0.061	-0.031 (-2.0)
Ln (By-Om-Grn / Forage Price)	-0.046 (-1.9)	0.009	0.055 (2.7)	-0.031 (-2.0)	-0.050	0.081 (4.1)
Dummy (West)				0.075 (2.4)	0.076	-0.151 (-4.1)
Dummy (East)				-0.045 (-1.5)	0.252	-0.207 (6.2)
Sheep Milk / Total Milk (Sheep + Goat)				0.180 (1.8)	-0.282	0.102 (0.9)
R ²	0.02		0.06	0.18		0.28
Average Value	0.44	0.19	0.37	0.24	0.36	0.39
Average Predicted	0.44	0.19	0.37	0.25	0.40	0.35
Minimum Predicted	0.38		0.21	0.11		0.13

Note: t-statistics are in parentheses. Bold denotes significance at the 5 percent level and italics denotes significance at the 10 percent level

Table 4. Price and Substitution Elasticity Tables

	Fed Sheep			Dairy Sheep		
	Price Elasticities					
	Formula Feed	Forage	Byprod., Meal, & Grain	Formula Feed	Forage	Byprod., Meal, & Grain
Formula Feed	-0.52	0.22	0.28	-0.53	0.07	0.31
Forage	0.53	-0.84	0.33	0.11	-0.69	0.18
Byprod., Meal, & Grain	0.33	0.15	-0.57	0.30	0.10	-0.53
	Morishima Substitution Elasticities					
	Formula Feed	Forage	Byprod., Meal, & Grain	Formula Feed	Forage	Byprod., Meal, & Grain
Formula Feed		0.74	0.80		0.60	0.84
Forage	1.40		1.16	0.80		0.86
Byprod., Meal, & Grain	0.89	0.72		0.83	0.63	

changes in feed prices. Forages account for 35 percent of total feed in the sector; however this share is very responsive to changes in formula feed and BY-M-G prices. In the dairy sheep sector forages play a much smaller role, accounting for roughly 17 percent of total feed. The BY-M-G aggregate accounts for more than 70 percent of total feed consumed by dairy sheep. In terms of nutrition, formula feeds and the BY-M-G aggregate serve very similar roles in the fed sheep and dairy sheep rations. Consequently, demand for formula feeds respond more to changes in the BY-M-G price index than to changes in the forage price index.

Impacts of Feed Quality

Two additional equations were estimated for the dairy cattle sector to obtain evidence of the impact of increased use of quality feeds on feed efficiency and productivity. Starting from equation (1), we assume the cost function is linear homogeneous in output, and we derive the

quantity of feed per unit of total output from the second-stage minimization of total cost. The optimal quantity of feed per unit of output (*UFI*) will depend on both the price index for feeds (p_2) and the price index for other inputs (p_1). We approximate the feed price index with the Stone price index for feeds using the sample average feed expenditure shares and reported prices to construct the index. As a proxy for the price of other inputs, we use the unit variable cost less unit feed costs. We add a regional dummy variable (*DW*), which has a value of one for producers in western Turkey, and the number of days spent on pasture (*MDW*) as additional explanatory variables. In order to capture the effect of feed quality on feed efficiency, we also include the share of formula feed in the total feed ration (*QQF*). The final regression equation is shown in equation (8)

$$(8) \quad UFI = \alpha_0 + \alpha_1(p_1) + \alpha_2(p_2) + \alpha_3(QQF) + \alpha_4(MDW) + \alpha_5(DW)$$

Equation (8) was estimated for over two data samples, producers milking cultured cattle and producers milking crossbred and domestic cattle. The results are displayed in Table 5. As expected, a greater share of quality feed in the total feed ration reduces the total quantity of feed per unit of output, hence, increasing feed efficiency. A 10 percent increase in the share of quality feed decreases unit feed use by 2 percent. The results from dairy producer milking cultured cattle were compared to those milking crossbred and domestic cattle. A Wald test was used to check for evidence that the parameters of the estimated equation for cultured cattle are significantly different from those estimated for other cattle. The test statistic reported in Table 5 does not exceed the critical value of 16.81; therefore, we accept the null hypothesis that the two types of cattle are equally impacted by increased feed quality.

The impact of feed quality on animal productivity is assessed by regressing output per cow on net revenues (*NREV*), a regional dummy variable (*DW*), the number of days spent on

Table 5. Feed Efficiency and Productivity Estimation Results

Dependent Variable	Cultured Cattle		Other Cattle	
	Unit Feed Input	Yield Per Cow	Unit Feed Input	Yield Per Cow
Constant	11.5 (2.4)	3567.8 (16.6)	38.0 (2.0)	2476.6 (8.4)
Net Returns		3.7 (2.6)		4.0 (4.4)
Feed Price Index	-0.8 (-1.8)		-3.2 (-1.8)	
Other Cost Index	35.1 (1.7)		67.4 (2.2)	
Quality Feed	-5.0 (-2.1)	2056.0 (2.4)	-7.4 (-1.9)	4420.3 (5.5)
Pasture	-0.004 (-1.2)	-0.06 (-0.6)	-0.02 (-1.6)	-3.6 (-2.4)
Western Dummy	-0.037 (-0.1)	300.0 (2.1)	-2.3 (-1.7)	691.5 (3.1)
R ²	0.282	0.216	0.328	0.578
Wald Statistic	4.2	144.2		

Note: t-statistics are in parentheses. Bold denotes significance at the 5 percent level and italics denotes significance at the 10 percent level

pasture (*MDW*), and the share of formula feed in the total feed ration (*QQF*). This yield equation was also estimated separately for cultured cattle and other cattle. The results in Table 5 indicate that increasing the share of quality feed has a substantial positive impact on milk output per cow. Unlike feed efficiency, the Wald test reveals that there is a significant difference in the impact of quality feed on output per cow. The test statistic of 144.2 soundly rejects the null hypothesis that the estimated coefficients are the same in both equations. Although this test does not allow us to separate out the effects of the feed quality variable, the coefficient estimates indicate that a 10

percent increase in the share of quality feed will increase output per cow by 2.3 percent for other cattle and only 0.7 percent for cultured cattle. Even though cultured cattle yields average nearly 50 percent higher than for domestic and crossbred cattle, the increase for cultured cattle is roughly half as large in absolute quantities as for other cattle.

Conclusions

The demand and input substitution elasticity estimates in this study indicated that Turkish producers consider quality formula feeds to be an integral part of their feed regime. As feed prices change, producers substitute grains, oilseed meals, and by-product feeds for formula feeds; however, the demand for lower quality feeds tends to be more elastic than for formula feed. Estimation of unit feed inputs and yields in the dairy cattle sector revealed that increasing quality feeds significantly improves feed efficiency and increases productivity. Although there does not appear to be a difference in the impacts of quality feed on feed efficiency for different breeds of cattle, yields of domestic and crossbred cattle increase nearly twice as much as cultured cattle.

In light of these results, government policies that increase the availability of formula feeds and quality feed ingredients could significantly improve Turkey's ability to meet its future demand for livestock products. Currently, the Turkish government supports domestic grain and livestock producers through support prices, input subsidies, and substantial import tariffs. Opening domestic markets to lower-cost imported feed grains is one policy option that would lower the cost and increase the availability of quality feedstuffs. In addition, policies that encourage producers milking crossbred and domestic cattle to increase their use of quality feeds will yield a short-run increase in milk output, while the long-run productivity of the herd can be raised by increasing the share of cultured cattle in the dairy herd.

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