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Short Communication

Production and Supply Response of Milk in Pakistan: Price and Non-price Determinants

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Abstract

The present study was designed to estimate milk supply response to price and non-price factors in order to devise appropriate policy for fetching competitive market price by the producers, encouraging investment in the dairy sector and thus, enhanced milk production. Cobb Douglas production function was employed to estimate the determinants of milk supply response function in Pakistan using ordinary least square (OLS) method. The study made use of time series data from the year 1972 onward. Results of the production function show that milk production is more responsive to non-price variables; whereas, it has relatively inelastic responsiveness to price factors. Thus, there is need to strengthen existing and/or create new infrastructure to facilitate the milk supply. © 2013 Friends Science Publishers

Keywords: Price and non-variables; Cobb douglas; Milk supply; Pakistan

Introduction

In spite of the fifth largest milk producing country in the world (FAO, 2011), Pakistan is still struggling to bridge a wide gap in the demand and supply of milk. It spends huge amount of financial resources to import milk and milk products to fulfill consumer needs (GOP, 2011; Mansoor *et al.*, 2012), despite the fact that milk production has increased overtime merely as a result of more animal population. This indicates that the national average yields are far below the levels achieved under the best farming practices, which may be attributed to many micro and macro factors. Micro factors may include level of production and reproductive efficiency of the herds (Ahmed *et al.*, 2000; Jainudeen and Hafez, 2000), degree of intensification and potential availability of input and support services (Uddin *et al*., 2010), poor management, feed shortage and low milk price (Nkya *et al.*, 2007). Only management interventions at dairy farms can substantially reduce expenditures and increase milk production and income of small farmers (Bayemi *et al.*, 2009). Macroeconomic factors comprise price and non-price factors. They are important, because they provide information to administrators who are responsible to maintain a rationale between milk production and consumption. The most important macroeconomic factors include per capita production, per capita income, change in the retail price (Anjum *et al.*, 1989), consumer price index, credit to dairy sector (Akmal, 1993), genetic progress and structural changes, relative price of milk (Wasim, 2005), price of cotton cake and rural infrastructure like road network, electrification, etc. Microeconomic studies relating to Pakistan show that factors having impact on milk production are fodder (Hussain *et al.*, 2010), selling price and cost of production of milk (Ghafoor *et al.*, 2010). Nevertheless, very few studies using macroeconomic variables are available on issue related to milk supply response in Pakistan. Available studies show that price elasticity of milk is inelastic (Anjum, *et al.*, 1989) to changes in milk prices and credit availability in short-run and long-run (Akmal, 1993; Wasim, 2005); whereas, genetic programs and other structural changes increase milk production significantly (Akmal, 1993).

Estimates of the supply response of milk production to price and non price determinants give valuable information for administrators who are responsible to maintain a rational balance between milk production and consumption. The present study at supply response of milk production is an attempt to include macroeconomic variables, such as milk price, loan for dairy sector, beef price and price of cotton cake, villages electrified, roads, number of animals in milk and fodder availability. Many of these variables are not considered in the previous studies conducted in Pakistan (Anjum *et al.*, 1989; Akmal, 1993; Wasim, 2005). Thus, the present study is an effort to estimate the response of milk producers to price and non price variables while making a decision about production allocation of milk. The findings of the study will be helpful to identify areas of interventions and making suitable policies to enhance milk supply in the country to shorten the widening gap between milk supply and demand.

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Materials and Methods

Supply Response Model and Estimation Process

Farm reared animals were milked and milk tested for quality. Data was processed and Cobb-Douglas production function was found as the most appropriate representative of the data because it yielded better results with respect to sign, values and levels of significance for regression estimators. A simple Cobb-Douglas function with two explanatory variables can be written in its stochastic form as:

$$Y_i = A_1 X_{2i}^{\alpha_2} X_{3i}^{\alpha_3} e^{u_i} \quad (1)$$

It is clear from the equation (1) that the relationship between output and the two inputs is nonlinear. However, the non-linear relationship can be transformed into a linear relation by taking logarithm on both side of equation (1). The transformed linear form of the function would be:

$$\ln Y_i = \alpha_1 + \alpha_2 \ln X_{2i} + \alpha_3 \ln X_{3i} + u_i \quad (2)$$

The above model is linear in parameters α_1, α_2 and α_3 and in logs of variables Y_i and X_i's; therefore, it is a linear regression model. The estimation of elasticities for double log function is quite convenient as parameters α_2 and α_3 directly give elasticities with respect to corresponding variables (Wooldridge, 2009).

Empirical Model

The Cobb Douglas type production function used in the present study can be written in non-linear form as under:

$$Q_i = A_1 (PM)_t^{\alpha 1} (PB)_t^{\alpha 2} (PB)_{t-1}^{\alpha 3} (PC)_t^{\alpha 4} (PC)_{t-1}^{\alpha 5} (Loan)_t^{\alpha 6} (MA)_t^{\alpha 7} (FA)_t^{\alpha 8} (RM)_t^{\alpha 9} (PV)_t^{\alpha 10} (Q)_{t-1}^{\alpha 11} De^{ut} \quad (3)$$

For the purpose of estimation, this nonlinear function was transformed into linear function by taking natural logarithm on both sides of equation (3):

$$\ln Q_i = \alpha_0 + \alpha_1 \ln(PM)_t + \alpha_2 \ln(PB)_t + \alpha_3 \ln(PB)_{t-1} + \alpha_4 \ln(PC)_t + \alpha_5 \ln(PC)_{t-1} + \alpha_6 \ln(Loan)_t + \alpha_7 \ln(MA)_t + \alpha_8 \ln(FA)_t + \alpha_9 \ln(RM)_t + \alpha_{10} \ln(PV)_t + \alpha_{11} \ln(Q)_{t-1} + \alpha_{12} D + u_t \quad (4)$$

Where,

Q_t = milk supply in year t ('000' tons)

$(PM)_t$ = price of milk (rupees per ton) in year t

$(PB)_t$ = price of the beef (rupees per ton) in year t

$(PB)_{t-1}$ = lag of price of the beef (rupees per ton) in year t -1

$(PC)_t$ = price of the cotton cake (rupees per ton) in year t

$(PC)_{t-1}$ = price of the cotton cake (rupees per ton) in year t-1

(Loan)t = Agricultural Development Bank of Pakistan (ADBP) loan advanced annually for dairy development purpose (million rupees)

$(MA)_t$ = number of animals in milk ('000' heads) in year t

$(FA)_t$ = fodder area ('000' acres) in year t

$(RM)_t$ = road mileage (km) in year t

$(PV)_t$ = progressive villages electrified in year t

$(Q)_{t-1}$ = Lag of dependent variable

D = dummy variable 1 for the year 1995-96 and onward and 0 otherwise

u_t = the error term (with OLS assumption) in the year t with the assumption that $u_t = N(0, \sigma_u^2)$.

As the data were time series, so data were tested for its stationarity by graphical, correlogram and autocorrelation function and unit root test. Non-stationary time series data were transformed into stationary data after taking first and second differences.

Source of Data and Description of Variables

The study is based on time series data starting from the year 1971-1972 onward. The data from the year 1971-1972 are taken because of the fact that this was the first time when data regarding milk production were available in Pakistan. The time series data were collected from the farm reared animals. These included different issues of Agricultural Statistics of Pakistan (GOP, 1986, 1993, 2002), Economic Survey of Pakistan (GOP, 2001, 2008) and Statistical Year Book of Pakistan (GOPa, 2002).

Ordinary least square technique was used in this study and regression was run on the log-log variation of the model. STATA 11 software was used to estimate the parameters of the supply response equation. Descriptive statistics of variables included in the model are given in Table 1. To estimate the milk supply response in the current study, two types of independent variables are included. They are price and non-price factors. The price variables included:

a) Price of milk (Rs/ton). Average retail price of buffalo milk in seven major urban centers in Pakistan was used as own price variable converted in rupees per metric ton. The price of buffalo milk was used due to: a) data on price of cow milk was not available for the study period; b) the prices of cow and buffalo milk during the period prior to 1970 (for which both series were available) were exactly the same or very close; and c) commonly cow and buffalo milk are not sold separately.

b) Price of beef (Rs/ton). In Pakistan, there are no data available for distinct breeds of cows or buffalos for milk and beef production. These can be considered as joint products. Therefore, price of beef in rupees per ton was also included in the model.

c) Price of cotton cake (Rs/ton).

The non-price variables include

a) Number of milking cows and buffalos ('000' heads). The milk supply also depends on the number of cows and buffalos in milk, therefore, the number in thousand heads of these animals were used as explanatory variables.

b) ADBP loan forward annually for dairy development purpose (million rupees)

c) Fodder area ('000' acres). A significant part of the feed is used for body maintenance and the rest is converted into milk. Therefore, quantity and nutritional composition of feed is an important variable affecting milk production. In Pakistan, fodders grown by the farmers make the major part of the feed source for animals. The other sources include weeds, ranges, roughages, and concentrates etc. For most of them the data series are not available and the others are used only in small quantities. As the data on prices, quantity of fodder, and types of fodder was not available, therefore, data on fodder area in thousand acres was used as feed variable.

d) Number of villages electrified. The infrastructure variables like electricity are expected to affect agriculture production positively, cumulative number of village electrified was used as one of the explanatory variables.

e) Road infrastructure in kilometers. The roads help in market accessibility and reduce transport cost (money and time costs) and transport losses. The road length in kilometers was used as an explanatory variable. It is expected to affect milk supply positively.

Dependent variable included in the model is quantity of milk supplied ('000' tons). Total quantity of the buffalo and cow milk produced (in '000' metric tons) was assumed to be equal to milk supplied. Milk of sheep and goat is excluded from milk production because their share is very low in total output at national level and most of it is fed to young stock and the rest is mostly used for family consumption and rarely marketed. The variables like number of veterinary hospitals, number of animals vaccinated and price of different feeds also are expected to affect milk supply and should have been included in the model. However, a complete series for a reasonable length on none of these variables was available and therefore, these variables were excluded from the model. It was observed that the data on milk production, after 1995 had a sudden upward jump. This may be due to some change in estimation procedure or revised methodology based on information from Livestock Census of 1996. To account for the effect of this sudden shift in milk production a dummy variable was included in the model and defined as one for year 1995-1996 and onward and zero otherwise.

Results and Discussion

The primary objective of this study was to estimate milk supply response function in Pakistan. The OLS estimates of Cobb Douglas production function are given in Table 1. The value of R square indicates that the explanatory variables included in the model fit the data quite well. As we have employed regression lagged dependent variable as an explanatory variable, Durbin-Watson d statistic is not reported. Breusch-Godfrey LM test and Durbin's alternative test for autocorrelation were used, which show that there exists no autocorrelation (null of no serial correlation is accepted at 1 percent level of significance). The coefficient of dummy variable is statistically significant which shows that there was some significant increase in milk supply after 1995 (it may be change in method of data collection or survey design, etc). Details of price and non-price factors are described below.

Price Factors

The coefficients of milk price, beef price in current year are positive and are statistically significant at one percent level of significance while beef price of previous year is statistically insignificant. According to our estimate one percent increase in milk price would result in about 0.29% increase in contemporaneous milk supply and one percent increase in beef price will increase milk production by 0.18%. Estimated price elasticity of milk supply is inelastic. Inelastic price of milk supply is also reported by Akmal (1993) and Wasim (2005). Although Chen *et al.* (1972) and Chavas and Kraus (1990) found the long run response of American milk producers due to change in milk price to be in the elastic range. However, Akmal (1993) was of the view that empirical literature about developing countries suggests that livestock producers are not price responsive compared to those of the developed countries. Results of the present study also show that milk producers respond to changes in milk price but response is inelastic as animals are kept at farms keeping in view their complimentary/ supplementary relationship and livestock farming is still traditional not a commercial enterprise.

Milk production and beef price move in the same direction because milk and meat are joint products and when in response to increase in beef price animals are increased, thus milk production increases automatically. Since beef and milk are joint products, therefore, it is possible that in response to increase in price of beef animals, their number will increase. It will lead to an increase in quantity of milk as indicated by positive sign in Table 2. However, in the short-run, this response is inelastic while with the lags it is insignificant showing that by increasing price of beef in one year, number of animals will be increased in next year but these increases would be specifically for the purpose of meat production as this does not lead to increase in milk production. Therefore, price of meat has insignificant impact on milk supply in the coming years in the long-run, although farmer can use them as dairy sector in the short-run.

Although, coefficient of the price of cotton cake variable has sign according to our expectation in the current year and the previous year but the coefficient is statistically insignificant i.e., this variable has no statistically significant impact on milk supply. The reason may lie in the fact that cotton cake is too costly to use as animal feed and it is mostly used by those dairy farmers who are using milk for home consumption; whereas, most of the dairy farmers producing milk for marketing purpose use wheat bran or such farmers make use of animal feeds which are available at much cheaper rate than that of cotton cake. This may be

Table 1: Summary statistics of variables

Variables	Mean±SD	Minimum	Maximum
Quantity of milk supplied ('000' tons)	18413±10997	7528	39378
Number of milking animals (000 no.)	10879±4435	5698	19578
Price of milk (Rs./ton)	9793±7254	1238	27380
Price of cotton cake (Rs./ton)	4009±3127	349	12223
Lag of price of beef (Rs./ton)	32387±31708	1701	120040
Loan advances by ADBP (Million Rs.)	631±551	0.26	1693
Road mileage (km)	163738±70023	74187	259197
Fodder area ('000' aces)	6562±295	5828	6987
Progressive villages electrified (Number)	39360±31508	2611	116573
Dummy	0.33±0.48	0	1

Table 2: OLS estimate of the milk response function

Variables	Coefficients	Std. error	t-statistics
Constant	-1.27***	0.38	-3.33
$(PM)_t$	0. 29***	0.06	4.85
$(PB)_t$	0. 18***	0.04	4.26
$(PB)_{t-1}$	0.04ns	0.03	1.25
$(PC)_t$	-0.03ns	0.02	-1.43
$(PC)_{t-1}$	-0.01ns	0.03	-0.32
$(Loan)_t$	-0.03***	0.004	-7.16
$(MA)_t$	0. 28***	0.08	3.58
$(FA)_t$	0. 47***	0.06	8.42
$(RM)_t$	0.38***	0.05	7.05
$(PV)_t$	0. 12***	0.02	5.18
$(Q)_{t-1}$	0.09**	0.04	2.23
D	0.30***	0.02	15.34
R^2	0.99		
Adjusted R^2	0.99		
Number of observations	36		

**** and ** show that coefficients are statistically significant at 1 and 5%, respectively; whereas, ns stands for non-significant; Q_t = milk supply in year t ('000' tons); $(PM)_t$ = price of milk (rupees per ton) in year t; $(PB)_t$ = price of the beef (rupees per ton) in year t; $(PB)_{t-1}$ = lag of price of the beef (rupees per ton) in year t -1; $(PC)_t$= price of the cotton cake (rupees per ton) in year t; $(PC)_{t-1}$= price of the cotton cake (rupees per ton) in year t-1; (Loan)t= Agricultural Development Bank of Pakistan; (ADBP) loan advanced annually for dairy development purpose (million rupees); $(MA)_t$= number of animals in milk ('000' heads) in year t; $(FA)_t$ = fodder area ('000' acres) in year t; $(RM)_t$ = road mileage (km) in year t; $(PV)_t$ = progressive villages electrified in year t; $(Q)_{t-1}$= Lag of dependent variable; D = dummy variable 1 for the year 1995-96 and onward and 0 otherwise; u_t = the error term (with OLS assumption) in the year t with the assumption that $u_t = N(0, \sigma_u^2)$

the reason that cotton cake has insignificant impact in milk production, thereby milk supply. Moreover, there are many close substitutes available to farmers. They include dry herds, wheat bran and prepared animal feeds (unfortunately, time series data is not available for the study period).

Non-price Factors

The coefficient of the number of animals in milk, fodder area, road mileage and number of villages electrified are positive and are statistically significant at one percent level of significance. Loan for dairy development is statistically significant at one percent level of significance but it has negative sign contrasting to *a priori* expectations. Reasons of inverse impact of loan on milk supply response may be the small amount of loan disbursed for dairy sector development purpose which cannot be used efficiently or its use may be deliberately inefficient/inappropriate use.

Milk supply was relatively more responsive to number of milking animals. One percent increase in the fodder area causes 0.28% increase in milk supply. Similarly, increasing milking animals by one percent can lead to an increase of 0.47% in milk supply. Road mileage causes more variation in milk response as compared to electrification in villages and fodder area, as one percent rise in the road mileage causes milk supply to improve by 0.38%, while contemporaneous milk supply increases by 0.12% when we increase village electrification by one percent. It is common observation that milk is collected by milkmen from almost all the villages, which are connected to the cities by metallic road. So, it is the case with milk processing companies, such as *Milk Pack*, *Nestle*, etc. The milk is collected only once in 24 h in the morning from different villages in a particular area. The collected milk is brought to small storages or plants installed by these companies in the electrified villages to secure the evening milk production. Overall results for non-price variables show that milk supply is more responsive to infrastructural changes in market as compared to price signals. Kavoi *et al.* (2010) argued that non-price factors are more important in supply response of dairy milk compared to price factors. However, Khan *et al.* (2010) describe that the differences of the prices of feed, milk, meat and breeds are other factors responsible for milk supply response.

Conclusion

The dairy sector in Pakistan is performing far below to its potential. To increase the supply of milk, market forces can be used to give the necessary signals for allocation of resources to dairy and other competing sub-sectors. Along with market forces, infrastructure improvement can also help to increase the milk supply. Road mileage, number of milking animals, progressive villages electrified and fodder area are important variables affecting milk supply followed by price of milk and beef in current year which have positive and significant effect on milk supply response in Pakistan. However, responsiveness to own price was much smaller as compared to road infrastructure. The higher elasticity of non-price variables, especially increase in number of milking animals implies that growth in production of milk is not due to an increase in productivity, so policy makers should divert their attention toward increasing productivity of dairy sector. Further, infrastructural improvements really matter for increasing supply of milk in the country. Milk producing regions need to be connected through a speedy transportation network and chilling centers should be established along the routes, where milk from the farms can be chilled on its way to the milk plants or markets. Loan for the dairy development should be provided in the way so that it can have significant effect on dairy sector improvement for increasing milk supply and its proper usage needs to be monitored in order to avoid wastage of financial resources.

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