Economics Bulletin

Volume 33, Issue 4

Beef and milk price links in Turkey

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Abstract

This article addresses the recent beef price spikes in Turkey, using contemporary time-series analysis. The arguments point to the impact of low milk prices that led to liquidation of dairy herds and decline of beef prices initially due to the liquidation and increased meat supply, and subsequent price increases in the next year due to decreased supply. The results revealed that dairy herd liquidation had a delayed impact of a year to 18 months on farm, wholesale, and retail beef prices. Those effects wore off over a two-year time period.

Journal Paper #13-04-112 of the Kentucky Agricultural Experiment Station. Funding was made available through the Bogazici University Research Fund 11C01P2.

Citation: Sayed H Saghaian and Gokhan Ozertan and Hasan Tekguc, (2013) "Beef and milk price links in Turkey", *Economics Bulletin*, Vol. 33 No. 4 pp. 2607-2616.

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Submitted: August 13, 2013. **Published:** October 08, 2013.

1. Introduction

Red meat prices have shown considerable increases since 2005 in Turkey. Overall food inflation rose 93 percent, retail beef prices rose 106 percent, and retail sheep prices rose 138 percent between 2005 and 2012 (TurkStat, 2013). In the same period, the animal feed index increased by 100 percent while retail milk prices increased by only 39 percent. Since Turkey is a major importer of animal feed ingredients, it is also influenced by developments in the world grain prices. In 2009, Turkey imported 96 percent of soybeans and 10 percent of maize consumed in the country (FAOSTAT, 2012). Grains and soy, major ingredients for dairy and beef cattle industries, have experienced serious price increases in recent years (OECD/FAO, 2011). World grain prices reached record levels in 2008 (Dorward, 2011) and beef prices responded strongly to grain price increases. The FAO Bovine meat index rose from 114 in January 2005 to 198 in December 2012, the highest level on record (FAO, 2013). The recent liquidation of dairy herd and limited imports has also contributed to the increase in red meat prices in Turkey. The number of sheep in the country has shown significant decreases and the number of cattle has stagnated.

The sharp increases in nominal retail prices in Turkey attracted the interest of both the press and policy makers. It is believed that the inability of milk prices to keep up with the overall inflation and main cost items have led to pre-mature culling of dairy herd. With the number of sheep showing significant decreases, the number of cattle stagnating, and limited meat imports, subsequent meat price spikes were triggered. Annual beef production in Turkey in the period 2005-2012 ranged between 645,000 to 916,000 tons, corresponding to slaughter of 3.5 to 5.3 million cattle. Beef production initially peaked in 2007- 2008, reaching 795,000 and 797,000 tons, respectively; in 2009 it was the lowest amounting to 642,000 tons. In 2012, it reached 916,000 tons, which included significant amount of live cattle imports that were slaughtered later. In the same period, production of red meat from small ruminants declined from 141,000 to 86,000 tons, which corresponds to a decline from 7.7 to 4.6 million animals slaughtered (TurkStat, 2013).

Evaluation of the organic price links between the milk and meat markets could help partially explain the reason behind recent beef price spikes. In this study, using contemporary time-series analysis, we investigate the dynamic relationships among these markets along the beef and milk supply chains. Impulse-response functions based on causal structures highlight the complex interplay among the milk and beef price variables in the model.

2. Background

Use of cattle as capital investment and how farmers' behavior lead to unexpected changes in supply has been researched in the literature in detail (Jarvis, 1974; Rosen *et al*. 1994; Aadland and Bailey, 2001). In particular, the literature has mostly concentrated on "cattle cycles," where such cycles are not only the result of lags in agricultural production stemming from gestation and maturation of animals, but also from economic behavior (Rosen *et al*., 1994, p.468). Regarding the economic influences, both demand and supply factors such as weather and herd health issues influence the cattle cycles (Crespi *et al*. 2010).

An important criterion that farmers use while deciding on when to send their cattle to slaughter is the close relationship between milk and meat prices. In 1983, the U.S. government offered cash to farmers who voluntarily reduced their milk output compared to a base year. Reducing cow numbers by culling still productive cows was the most straightforward mean to qualify for government incentives. Bobst and Davis (1984 and 1985) investigated the likely effects of more than normal culling of dairy herd on the beef prices and beef cow herds in the U.S. They predicted an immediate decline in beef price as a result of culling of dairy herd compared to no liquidation policy. However, by year-end two prices rebounded above what would have been at the no liquidation policy. Depending on the level of liquidation in year one, more initial liquidation leads to more rebound in prices in year two and prices revert back to no liquidation levels starting at year four. Following the theoretical exposition in Bobst and Davis (1985), a positive link between milk and beef prices is expected.

Marsh (1988) also investigated the effects of 1986-1987 dairy termination programs on beef prices. He employed reduced form equations in time-series econometric analysis to investigate the causes of price changes at the farm-gate and wholesale levels. He found that prices declined between 4.6 and 6.4 percent at various levels due to dairy termination programs. The prices were back to equilibrium levels after six to eight quarters. Finally, in a more recent study, Rezitis and Stavropoulos (2012) looked at the meat markets in Greece. The authors showed a change in milk prices affect the meat supply in the opposite direction, implying that decreases in milk prices lead to increases in meat prices and subsequently supply.

These articles anticipated an initial decline of beef wholesale prices due to the liquidation of dairy herd and subsequent price increase in the following years. Unlike the above cases, the liquidation of dairy herd that took place in Turkey during 2007-2008 was not policy induced, but was as a result of the decline in farm-gate milk prices and the price squeeze felt by dairy farmers due to increasing feed costs. The chain of cause and effect can be summarized as the following:

- Excessive culling of dairy cows in 2007-2008 led to increased supply of slaughtered animals which depressed wholesale beef prices temporarily due to the sudden increase in beef supply.
- Declining real beef prices in the 2007-2008 period, in return, led to a declining calf crop starting in 2008. That was because fewer cows in the current period also meant fewer calves in the subsequent periods.
- The real beef prices eventually responded to the shortage of cow and calf stocks and, subsequently, beef prices began to rise.

In this article, we aim to verify those relationships between milk and beef prices at each end of the chain of causality. We use time-series techniques, namely co-integration, Granger causality, and impulse-response functions analysis to investigate the price links between these markets.

3. Data Description, Model Development, and Empirical Results

3.1. Price Data

For the analysis, we use prices from January 2005 to December 2012. The data used is collected officially and announced publicly by the Turkish Statistical Institute (TurkStat). Monthly price data for beef and milk are available at all levels along the supply chain and has been collected using the same methodology since 2005. All prices are in Turkish Lira per kilogram for beef and per liter for milk. Also, all prices are deflated with the consumer price index (CPI). Table 1 shows the summary statistics for the price series.

Table 1: Descriptive Statistics for Farm-gate, Wholesale, and Retail Prices Deflated by CPI

	Mean	Median	St. Dev.	CV	Minimum	Maximum
Farm-gate						
milk	0.50	0.51	0.05	0.10	0.40	0.59
beef	5.48	4.16	0.90	0.16	4.45	7.54
Wholesale						
milk	0.45	0.44	0.03	0.06	0.41	0.52
cattle	7.09	6.93	0.81	0.11	5.76	9.21
Retail						
milk	1.15	1.13	0.10	0.09	0.96	1.43
beef	10.98	10.33	1.31	0.12	9.41	14.42

3.2. Econometric Model Development

3.2.1. Cointegration

First, the standard augmented Dickey-Fuller (ADF) unit root tests were specified to investigate a cointegration relationship. The test is the same as checking the series for unit roots to see if they are random walk, that is, their mean and variance are not constant over time. The null hypothesis is that the series are non-stationary. The non-stationary series are integrated of order one or I(1) with the first-differences being stationary or I(0). With a MacKinnon 10 percent critical value, we failed to reject the null hypothesis of a unit root for the time-series variables. We also used seasonal unit root test with both seasonal Dickey Fuller and more general HEGY (Hylleberg, Engle, Granger, Yoo (1993)), and the results were consistent indicating the series to be I(1) in level. Hence, we have enough evidence to assume unit roots even after controlling for seasonality.

ADF test can also under-reject when there are structure breaks in series with deterministic trends and prior to ADF, test for structure breaks are recommended. We ran the Zivot and Andrews (1992) tests allowing for breaks with both intercept and trend. Both tests showed the series were I(1) in levels, again consistent with the ADF test results. Each series was then first differenced and the ADF regressions were re-estimated. In each case, we rejected the null hypothesis of a unit root at the 1 percent level of significance (the results not shown but are available upon request.) Then, Johansen's cointegration tests were employed to determine whether a long-run relationship existed among the price series. The cointegration test showed that the series were cointegrated and there were three cointegrating equations at the 0.05 level, as presented in Table 2.

Table 2: Cointegration Test Results

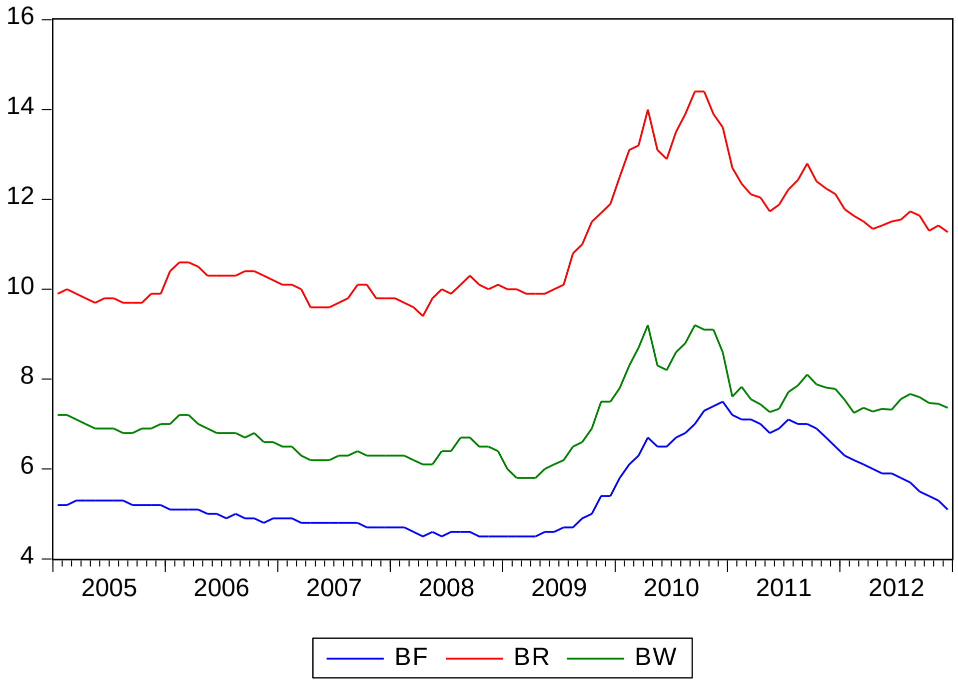
Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.502838	153.8181	95.75366	0.0000
At most 1 *	0.373721	92.32029	69.81889	0.0003
At most 2 *	0.270340	51.13988	47.85613	0.0238
At most 3	0.173868	23.40437	29.79707	0.2268
At most 4	0.067930	6.596277	15.49471	0.6250
At most 5	0.004599	0.405677	3.841466	0.5242

Trace test indicates 3 cointegrating equations at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

3.2.2. Granger Causality

To provide a clear causality direction among the milk and beef series, we employed pairwise Granger causality tests to investigate causal directions. The Granger causality tests were performed with series in first-difference with the vector error-correction model. First, the excessive culling of dairy herd may explain the muted response of the beef prices in Turkey during the 2008, when grain prices spiked (Figure 1).



BF: farm level beef prices; BW: wholesale beef prices; BR: retail beef prices

Figure 1: Monthly Beef Prices in Turkey (Turkish Lira Per Kilogram)

Since the level of liquidation in year one leads to rebound in prices in year two and the fact that our data set is monthly, to investigate the impact of liquidation we chose to look at a time lapse of 12 to 18 months for beef prices to increase. The results of statistically significant variables for two periods 12 and 18 months are summarized in Tables 3 and 4, and Figures 2 and 3, respectively. The F-test results indicated that wholesale milk prices played a pivotal role, Granger causing beef prices at all three farm, wholesale, and retail levels. The Granger causality results for 24 months were obtained, but were statistically insignificant. Seemingly, those effects wore off over a two-year time period.

Table 3: Pairwise Granger Causality Test Results Over 12 Months

Null Hypothesis:	F-Statistic	Prob.
MF does not Granger Cause BR	1.67445	0.0962
MW does not Granger Cause BF	2.80891	0.0042
MW does not Granger Cause BW	2.12456	0.0286
MW does not Granger Cause BR	2.55033	0.0087
MR does not Granger Cause BW	1.92281	0.0497

Sample: 2005M01-2012M12. MF: farm level milk prices; MW: wholesale milk prices; MR: retail milk prices; BR: retail beef prices; BF: farm level beef prices; BW: wholesale beef prices.

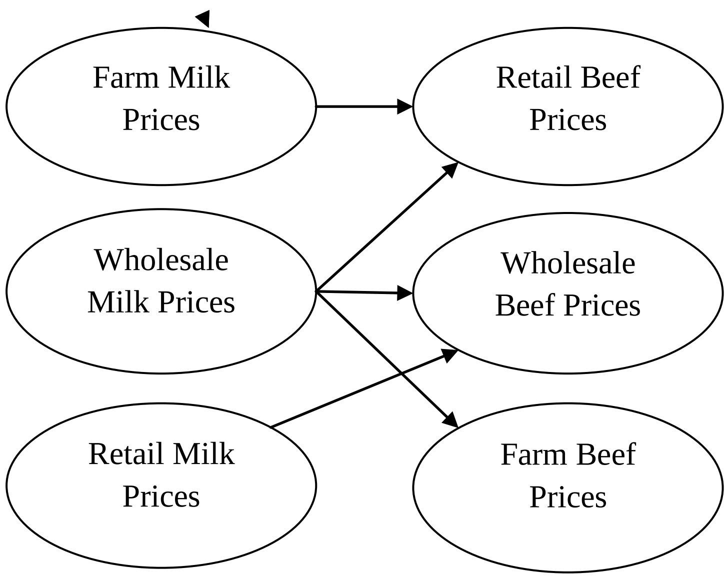


Figure 2: Granger Causality Results for the Milk-Beef Relationships Over 12 Months

Table 4: Pairwise Granger Causality Test Results Over 18 Months

Null Hypothesis:	F-Statistic	Prob.
MW does not Granger Cause BF	2.07471	0.0268
MW does not Granger Cause BW	2.37005	0.0112
MW does not Granger Cause BR	2.01708	0.0317
MR does not Granger Cause BW	2.46510	0.0085

Sample: 2005M01-2012M12. MF: farm level milk prices; MW: wholesale milk prices; MR: retail milk prices; BR: retail beef prices; BF: farm level beef prices; BW: wholesale beef prices.

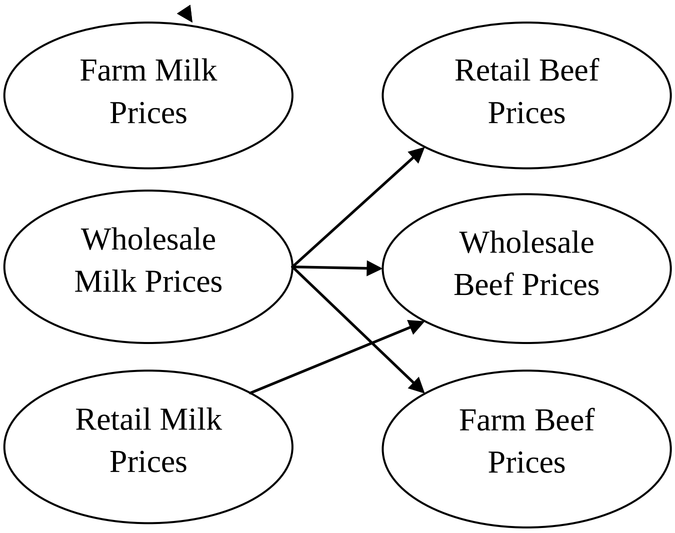


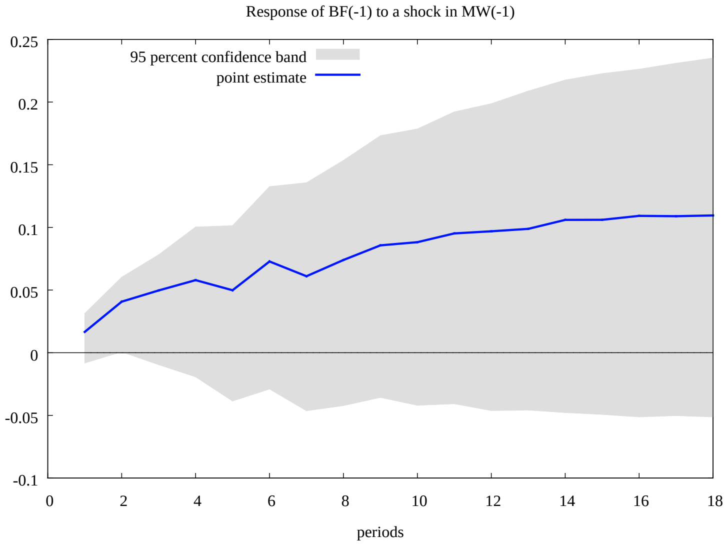
Figure 3: Granger Causality Results of the Milk-Beef Relationships Over 18 Months

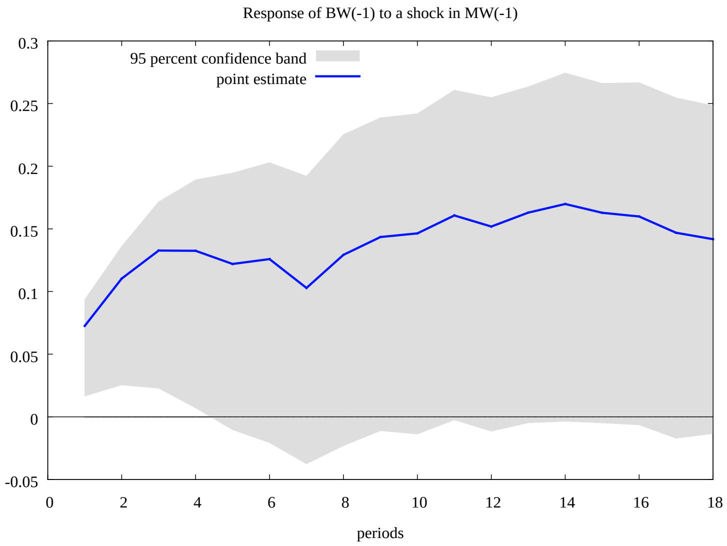
3.2.3. Impulse Response Functions

An impulse response function tracks the evolution of economic impacts through the system. It traces the response of current and future values of an endogenous variable (e.g., beef prices) to a one standard deviation change to one of the innovations (i.e., wholesale milk prices in this case). Any inference on responses of beef prices to changes in milk prices requires a careful investigation of correlation among corresponding innovations. In a case where contemporaneous correlation among the errors are present, calculation of impulse response functions may be distorted because of the effects of innovations in another variable in the system at the same time. A formal test of causal structures was performed using Granger causality before calculating the impulse-response functions.

The corresponding impulse response functions for farm (BF, first-differenced), wholesale (BW, first-differenced), and retail (BR, first-differenced) beef prices from a one standard deviation change in wholesale milk prices (MW, first-differenced) over the 18 month forecast horizon are presented in Figure 4. The focus is on wholesale prices because

Granger causality results (Figure 3) showed wholesale-milk prices had a pivotal role for the milk-beef relationships. Impulse response functions showed that beef prices were responsive to the wholesale-milk price changes and continued to increase for 6 months. After that, they declined but rose again until reaching close to the previous levels after 18 months. However, the effects for the wholesale beef prices were statistically significant at the five percent level only for the first four months. Farm-beef prices had a more stable pattern and did not level off to previous levels. Wholesale and retail beef prices were overall more volatile.





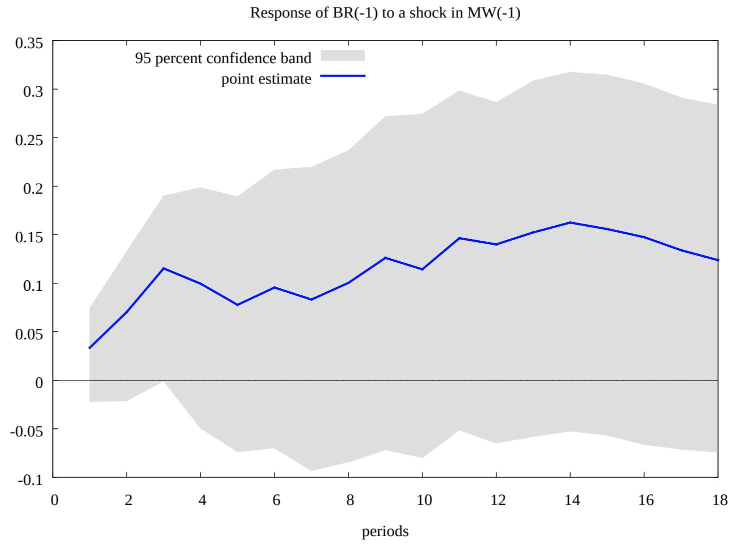


Figure 4: Impulse Response Functions. Responses of Beef Prices to shocks in Wholesale Milk Prices

4. Summary and Conclusions

In this study, we used monthly price data to analyze the relationship between milk and beef markets in Turkey. First, using a cointegration analysis, we found that there were three cointegrated vectors among the price series. Second, using Granger causality, we showed that causality existed between milk and beef price series with wholesale milk prices playing a pivotal role. Finally, impulse response functions traced the responses of beef prices to a one standard deviation change to wholesale milk prices over an 18 months horizon, showing the positive influence of milk prices on beef prices.

Cows are not only consumption goods but are also investment goods. In countries like Turkey almost all cows are dairy cows with a dual purpose, and almost all calves, including the males destined for fattening, are born in either traditional or dairy farms. Above the average culling of still-productive cows results in supply shortages in subsequent years both because of premature culling of cows and because of missing calves and heifers. There is an initial decline of beef prices due to the liquidation of dairy herd, but, consequently, prices increase in the following years. Hence, in this case, milk prices are the primary determinant of beef prices and our empirical results are consistent with that expectation. Also, these results are consistent with the literature previously discussed (i.e., Bobst and Davis, 1984 and 1985).

Results obtained are important for policy development regarding dairy and beef markets. In particular, it points to the crucial role of policy makers and supply chain managers in charge of nation’s food security. The results are expected to influence subsidies provided by the government to these markets. Such policy goals are to support producers and provide sustainable supply of milk and red meats in the country. It is also important for consumers, the products they purchase, and the prices they face. They demand access to affordable dairy and beef products, which take a sizable share of their consumption budget. Integrated macro level policies regarding dairy and beef markets may be more helpful rather than separate policy recommendations, given the organic nature of links between these two markets.

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