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Analysis of Farm-Gate-Retail Price Transmission in the Formal Milk Market in Kenya

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Abstract: *Testing for price transmission and calculating elasticities of price transmission are of great importance in applied economics. The relationship between farm-gate and retail prices provides insights into marketing efficiency as well as consumer and producer welfare. National average monthly price data for raw milk and pasteurized milk from January 2006 to December 2015 was used for the study. The time series data was obtained from Kenya Dairy Board statistical bulletins. To determine the nature of price transmission, Threshold Autoregression model (TAR) and Momentum Threshold Autoregression model (M-TAR) were used. The summary statistics indicated that retail prices had a higher mean (KShs. 65.551) compared to farm-gate (Kshs.27.117). Similarly, the range was high for retail prices (KShs. 60) as compared to that for farm-gate (KShs. 20.44). The elasticity of price transmission was 3.14 which indicated that retailers exercise more power than producers. The speed of adjustment to long run equilibrium was 26.83 percent. Granger causality tests indicated bidirectional causality and the TAR and MTAR models indicated presence of threshold cointegration and asymmetric price adjustment in the Kenyan milk market. The study concluded that the LOP does not hold and thus recommends government support through development of infrastructure so as facilitate storage and transportation of milk to the market. More emphasis should be placed on formation and strengthening of cooperatives so as to improve the bargaining power of producers.*

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DEFINITION OF TERMS

Asymmetry: Difference in adjustment to a price shock depending on whether the price shock is positive or negative and at what stage of the supply chain the shock occurs (farm, processing, wholesale or retail)(Capps and Sherwell, 2007).

Horizontal price transmission: The pass through of price shocks from one regional market to other regional markets(Serra and Goodwin, 2003).

Law of one price: An economic law which states that in an efficient market all identical goods must have only one price(Esposti and Listorti, 2013).

Magnitude of adjustment: The size of a price change at a particular level of supply chain due to a shock of a certain size at another level of supply chain (Vavra and Goodwin, 2005).

Market power: An ability of a firm (s) to raise and maintain price above the level that would prevail under perfect competition (Frey and Manera, 2005).

Nature of adjustment: An adjustment following a positive or negative shock which could either be symmetric or asymmetric (Frey and Manera, 2005)

Speed of adjustment: The time lag needed for a shock at one level of supply chain to be transmitted (partially or fully) to another level of supply chain. (Abunyuwah, 2007)

Threshold level: Refers to the smallest price change for which benefits exceed costs and price adjustment actually takes place. (Vavra and Goodwin, 2005).

Vertical price transmission: A pass through of price shocks along the supply chain (Serra and Goodwin,2003)

1.1 Background Information: Market price is the central mechanism by which different levels of markets are linked. The relationship between the producer, wholesaler and retailer prices provides insights into the marketing channel efficiency and the degree of market competition (Weldesenbet, 2013).Wohlgenant (2001) in a survey on marketing margins identified some of the questions puzzling researchers and policy makers alike. For example;Are marketing margins too large? Why are margins different among products? How have margins changed over time? What is the incidence of marketing costs on retail prices and farm prices? How quickly are farm prices transmitted to the retail level and vice versa? What is the relationship between concentration and market power? Is increased concentration detrimental or beneficial to producers?

Price transmission can either be symmetric or asymmetric. If the price transmission between the specific stages of the supply chain is asymmetric, then the price changes at the production level are not passed to the processing and/or retail level quickly or fully as in the case of symmetric transmission (Reziti and Panagopoulos, 2008). Price asymmetries could be negative or positive depending on their effect. A positive (negative) price asymmetry occurs when a decrease (increase) in prices at the farm level is not fully or immediately transmitted, but an increase (decrease) passes on more quickly or fully to the final consumer (Vavra andGoodwin, 2005). Price asymmetries are important because they usually have a negative impact on welfare (Meyer, 2004;Hahn, 1990).

Price transmission studies have focused on the potential for asymmetries in the adjustment of prices at different levels of the market. Several theoretical and institutional reasons that may bring about asymmetries have been offered. First, those agents possessing perishable goods may not increase prices to avoid the risk of being left with spoiled products(Ward, 1982).

Market power could be a second cause of asymmetry though it may not be the only causal factor. Peltzman (2000) argues that asymmetric price transmission may be characteristic of competitive as well as oligopolistic market structures and it cannot simply be concluded that presence of asymmetric price transmission automatically implies market power.

Different costs of adjustment, depending on whether prices rise or fall, might be a third cause (Bailey and Brorsen, 1989). Different price elasticities at different levels of the marketing chain may be a fourth reason. Finally, public intervention to support producer prices could also cause asymmetry (Kinnucan and Forker, 1987).

Meyer andvon Cramon-Taubadel (2004) observe that a possible implication of asymmetric price transmission is that consumers are not benefiting from a price reduction at the producers' level, while producers might not benefit from a price increase at the retail level. Thus, under asymmetric price transmission, the distribution of welfare effects across levels and among agents following shocks to a market will be altered relative to the case of symmetric price transmission (Vavra and Goodwin, 2005).Peltzman(2000) argues that asymmetric price transmission is the rule, rather than the exception.He concludes that since asymmetric price transmission is prevalent in the majority of producer and consumer markets, standard economic theory that does not account for this situation must be incorrect.

1.2 Problem Statement: Price transmission is an important element of linked markets that produce value-added goods. Agricultural efficiency results to a large degree from the perfection of the price mechanism in the system of agents' relationships. Hence, rising food prices might provide an opportunity for agricultural development if price changes at one market level (retail) are efficiently transmitted to another market level (farm-gate) (Kharin, 2015).

The study of asymmetric price transmission throughout the agricultural product supply chain provides insights into market efficiency and welfare of consumers and producers (Capps and Sherwell, 2007). In the case of agricultural products, asymmetric price transmission is caused by several factors including abuse of market power (von Cramon-Taubadel and Meyer, 2000), product perishability (Ward, 1982) and distortion in the price reporting process (Bailey and Brorsen, 1989; Cutts and Kirsten, 2006). The aforementioned research was done based on data from developed countries, while the present study extends into the study of asymmetric price transmission in Kenya which is a small developing country. There is not much research on price transmission based on data from other developing countries.

The extent of adjustment of retail prices to changes in farm gate prices is key in determining the consumer and producer welfare and indicating the presence of any inefficiency in the marketing system. These price adjustments along the supply chain cannot be solely explained by processing cost or other considerations, but possibly by the existence of significant market power resulting from the non-competitive markets(Ettema, 2012). Therefore the study aimed at analyzing farm gate- retailprice transmission in the Kenyan milk market with the view of providing relevant policy recommendations to the various stakeholders in the sector.

1.3.1. General Objective: The general objective of the study was to analyze farm-gate to retail price transmission in the Kenyan formal milk market.

1.3.2 Specific Objectives: The specific objectives of the study were;

i) To determine the short run and long run relationships between farm-gate raw milk prices and retailpasteurized milkprices in the Kenyan milk market.

ii) To determine the nature of price transmission in the Kenyan formal milk market

1.4 Hypotheses: The study tested the following null hypotheses;

$H_0$1: There are no short run and long run relationships between farm-gate raw milk prices and retail prices of pasteurized milkin the Kenyan milk markets.

$H_0$2: There is no price asymmetry in the Kenyan formal milk market.

2.1The Concept of Price Transmission: Price transmission refers to how prices in one market/market level are linked toprices in another market/market level. It is generally measured in terms of the transmission elasticity, defined as the percentage change in the price in one market/market level given a one percent change in the price in another market/market level (Minot, 2011). There are two types of price transmission which can be used to describe markets. These are horizontal and vertical price transmission. They are used to describe the type of linkages that exist in a market whether they are integrated along the supply chain or in space.

The interest in marketing margins and price transmission has recently gained remarkable momentum and the number of studies on this subject is rapidly growing. There is a myriad of questions about prices and margins investigated by these studies, despite the fact that new questions are arising even as markets and business practices change with an impressive speed (Vavra and Goodwin, 2005).

The distinction between short run and long run price transmission is important and the speed by which prices adjust to their long run relationship is essential in understanding the extent to which markets are integrated in the short run. Changes in the price at one market level may need some time to be transmitted to other market levels for various reasons such as policies, the number of stages in marketing and the corresponding contractual arrangements between economic agents, storage and inventory holding and delays caused in transportation or processing(Tuyishime, 2014). Price transmission measures, therefore, are important as they indicate how price changes move from one market to another or from one stage of a supply channel to another.

The theory of price transmission is premised on the Law of One Price (LOP), which follows from the spatial arbitrage condition that transfer cost adjusted prices are the same across spatially separated markets (Fackler and Goodwin, 2002). The Spatial Arbitrage condition can be specified as;

$$P_t^1 - P_t^2 \leq C_{12} \quad \text{.....(2.1)}$$

where P indicates the price in the two markets / market levels 1 and 2 and C_{12} is the cost of moving the good considered from market level 1 to 2.

Since upstream and downstream prices are related, the theory of price transmission is derived from the law of one price (LOP) which states that for a given commodity a representative price adjusted for allowance for transaction costs will prevail across all markets. The LOP plays an important role in models of price transmission in addition to relating the impact of market arbitrage on the prices of identical commodities that are exchanged in two or more markets/market levels (Fackler and Goodwin, 2002).

In absence of external shocks, some kind of economic equilibrium relationship between those two market levels should exist and external shocks to the system (that is shocks to downstream or upstream prices) should trigger short-run and long-run adjustment towards the long-run equilibrium. This is because rational economic agents price their goods so as to maximize their constant utility function and in the long run prices of goods should reflect their scarcity (Minot, 2011).

Apart from the LOP, other theories which can be used to explain price transmission are Porters Five Forces Model (Porter, 1980; Brooks and Melyukina, 2004),Deviation from Perfect Competition Model (PCM)(Listorti, 2009).Meyer and von Cramon-Taubadel, 2002),Institutional Theory(Williamson, 2000; Lutz *et al.*, 2006b), Supply Chain Theory (Vavra and Goodwin, 2005; Uchezuba, 2010),Neoclassical Theory(Balcombe and Morrison, 2002)and Structuration Theory(Frey and Manera, 2005).

3.1Research Design: In this study,longitudinaltime series research designwasused.In a longitudinal design data is collected over a long period of time. A time series design is whereby data is collected at a sequence of points, measured typically at successive times, spaced apart at uniform time intervals (weekly, monthly or yearly) (FAO, 2003).

3.2 Data Types and Sources: The data for this study was obtained from secondary sources. The major source of data was Kenya Dairy Board statistical year books. Data on monthly prices for both retail prices for pasteurized milk and farm-gate prices for raw milk were used for the empirical analysis.The time series price data that was used comprised of 10 year monthly prices of raw milk and retail prices for pasteurized milk for the period January 2006 to December 2015. The price data obtained was average price for the whole country which is an aggregation of prices from various regions.

3.3Analytical Framework: Before data analysis using analytical and descriptive methods was done, the data was entered into excel spread sheets of the computer and organized. The empirical analysis was done using Eviews 8.0, Stata 12.0 and R 3.2.4softwares. Descriptive analysis was done by use of tables and graphical plots. The mean, range and standard deviation were used to describe the data.

3.3.1 Threshold Autoregressive Model (TAR): Based on the TAR model a price shock has to reach a certain critical level before an adjustment can occur. The model accommodates both non linearities as well as asymmetries of price adjustment following a shock (Abdulai, 2007). The specification of the threshold models starts with the estimation of the Engel-Granger relationship below;

$$P_t^1 = \alpha + \beta P_t^2 + \mu_t \quad \text{.....(3.14)}$$

Where P_t^1 and P_t^2 are the prices at market levels 1 and 2 respectively at time period t, α is the intercept term, β is the coefficient to be estimated and μ_t is the error term. Engel and Granger (1987) introduced asymmetric adjustments by letting the deviations from the long-run equilibrium in equation (3.15) TAR process:

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1-I_t)\rho_2\mu_{t-1} + \varepsilon_t \quad \text{......} \quad (3.15)$$

Where I_t is the Heaviside indicator function so that:

$$I_t = \begin{cases} 1 \text{ if } \mu_{t-1} \geq \tau \\ 0 \text{ if } \mu_{t-1} < \tau \end{cases} \quad \text{......} \quad (3.16)$$

Where τ denotes the threshold value. Assuming the system is convergent $\mu_{t-1} = 0$ can be considered as the long-run equilibrium value of the sequence. If μ_{t-1} is above its long-run equilibrium value, the adjustment is $\rho_1\mu_{t-1}$ while the adjustment is $\rho_2\mu_{t-1}$ if below its long-run equilibrium. The adjustment is symmetric if $\rho_1 = \rho_2$ while asymmetry occurs if $\rho_1 \neq \rho_2$.

Equation 3.15 does not fully capture the convergence of $\Delta\mu_t$ towards long run equilibrium hence the lagged dependent variable values are added in order to ensure that the residuals are white noise;

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1-I_t)\rho_2\mu_{t-1} + \sum_{i=1}^{p}\delta_i\Delta\mu_{t-1} + \varepsilon_t \quad \text{......} \quad (3.17)$$

The null hypothesis tested in the threshold model was $\rho_1 = \rho_2 = 0$ that is, there is no cointegration. If the null hypothesis of no cointegration is rejected, then a standard F-test of symmetric adjustment is performed by testing if $\rho_1 = \rho_2$. Positive asymmetry exists if $|\rho_1| < |\rho_2|$ whereas negative asymmetry existed if $|\rho_1| > |\rho_2|$.If both null hypotheses are rejected it implies threshold cointegration and asymmetric adjustment.

3.3.2 Momentum Threshold Autoregressive Model (M-TAR): If the adjustment is asymmetric to the degree that the series exhibits more "momentum" in one direction than the other the resulting model is termed Momentum Threshold Auto-regression (M-TAR) process. The process is formally specified as:

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1-I_t)\rho_2\mu_{t-1} + \varepsilon_t \quad \text{......} \quad (3.18)$$

where I_t is referred to as the Heaviside indicator function such that;

$$I_t = \begin{cases} 1 \text{ if } \Delta\mu_{t-1} \geq \tau \\ 0 \text{ if } \Delta\mu_{t-1} < \tau \end{cases} \quad \text{......} \quad (3.19)$$

Where τ represents a threshold value.Thefirst null hypothesis tested in the M-TAR process is $\rho_1 = \rho_2 = 0$ that is, there is no cointegration. The test statistic is compared to critical values provided by Enders and Siklos (2001) when the point estimates of ρ_1 and ρ_2 imply convergence ($\rho_1 < 0, \rho_2 < 0$). Following a rejection of the null hypothesis of no cointegration, a standard F-test of symmetric adjustmentis performed by testing if $\rho_1 = \rho_2$. If both null hypotheses are rejected it implies threshold cointegration and asymmetric adjustment. If $|\rho_1| > |\rho_2|$, the M-TAR model exhibits little decay for negative $\Delta\mu_{t-1}$ but substantial decay for positive $\Delta\mu_{t-1}$. Thus, decreases tend to persist but increases tend to revert quickly toward the attractor and vice versa. Positive asymmetry exists if $|\rho_1| < |\rho_2|$ whereas negative asymmetry exist if $|\rho_1| > |\rho_2|$.

In the M-TAR model, if asymmetric cointegration is confirmed following rejection of $H_0 : \rho_1 = \rho_2 = 0$ and $H_0 : \rho_1 = \rho_2$ it is concluded that there is a long run relationship and the rate of adjustment following a positive shock differs from the rate of adjustment following a negative shock.One appealing feature of these models is that asymmetric behavior is identified through the data itself rather than through segmentation procedures(Minot, 2011).

4.1 Descriptive Statistics of Milk Prices: Two monthly milk price series (farm-gate raw milk prices and retail prices for pasteurized milk) were used in the study and were measured in Kenya shillings per liter. Table 4.1 shows the summary of the descriptive statistics which include mean, maximum, minimum and standard deviation for each of the two price series. The highest price recorded in the study period for pasteurized milk was Kshs 100 and Kshs 38 for raw milk while the minimum price for pasteurized milk was Kshs 40 and Kshs 17.56 for raw milk.

Table 4.1: Summary of Descriptive Statistics

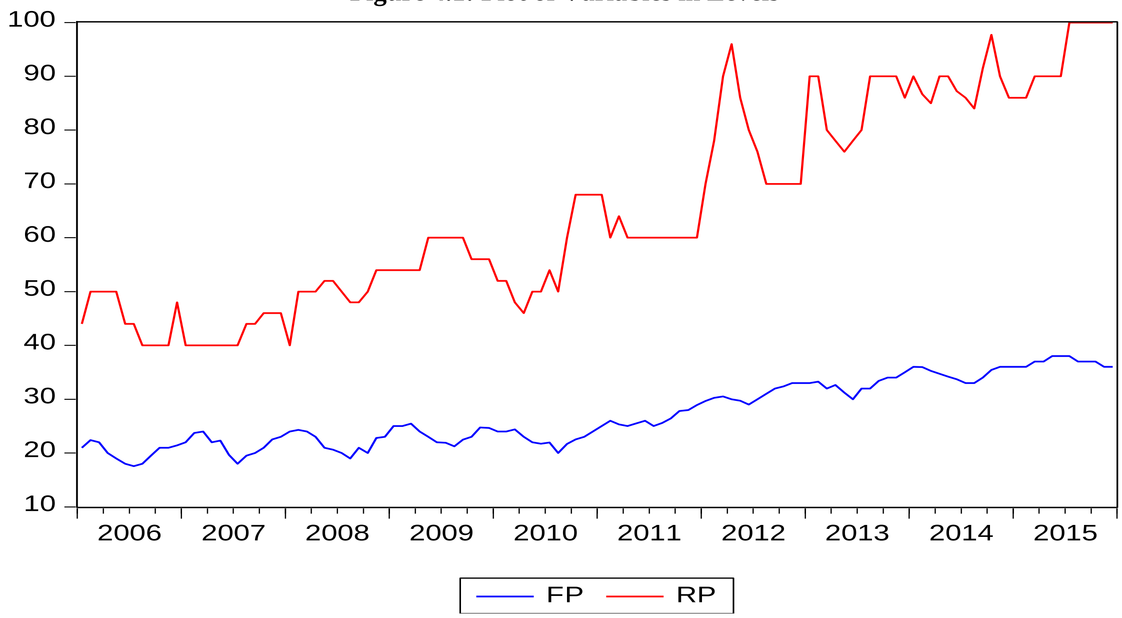
Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Retail price per liter	120	65.551	18.915	40	100
Farm gate price per liter	120	27.117	6.034	17.76	38

Source: Research Findings, 2016

A plot of the two price series is shown in Figure 4.1 below. Generally, the prices have been rising with the lowest prices for both pasteurized milk and raw milk being reported in some months of 2006 and 2007 and the highest being reported in 2015. The highest price for pasteurized milk was reported between July-December in 2015 and between May and July for farm-gate prices. The lowest prices for pasteurized milk were reported in 2006 (September-November) and 2007 (January-July).

In general, the price range was large in retail price than in farm-gate price in that the difference between the highest and the lowest prices for retail and farm-gate where Kshs. 60 and Kshs. 20.44 respectively. This could attributed to the increase in demand for processed milk by consumers especially urban dwellers and the inability of producers to bargain for higher prices for their raw milk as they lack cooperatives and specialized storage facilities which are necessary in marketing of the commodity (Muriuki, 2011).

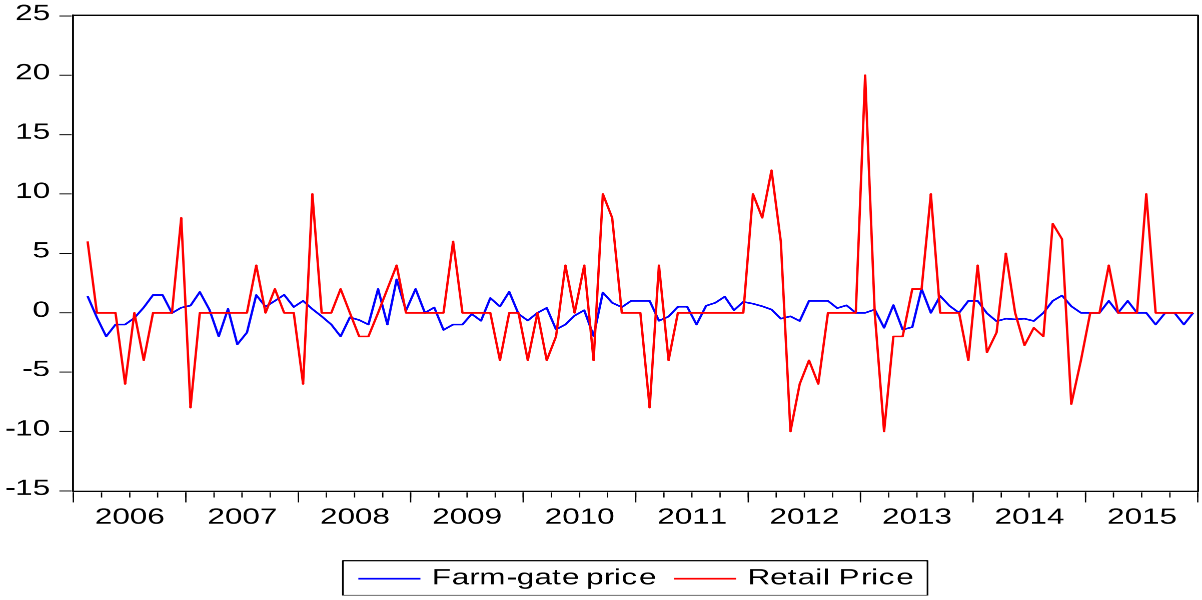
Figure 4.1: Plot of Variables in Levels



Source: Research Findings, 2016

Figure 4.2 shows a plot of the two variables at first difference. The graph shows that there is co-movement of prices. This can be shown by price movements in 2007, between 2008 and 2009 and in 2013.

Figure 4.2: Plot of Variables in First Difference



Source: Research Findings, 2016

4.2.1 Unit Root Tests: In testing for unit roots the ADF and PP tests were used. A summary of the results of ADF and PP unit roots tests at 5 per cent significance level is given in table 4.2. The results showed that all variables were non-stationary at levels but were all stationary at first difference. Therefore, the series under the study were first difference stationary.Having tested for unit roots and found that the price series were first difference stationary the study proceeded to test for cointegration.

Table 4.2: Unit Root Tests

Price		ADF		PP		Conclusion
		T	P-value	T	P-Value	
Level	Retail	-1.0713	0.7255	-0.4732	0.8914	Non-stationary
	Farm-gate	-0.5805	0.8696	-0.7758	0.8220	Non-stationary
Difference	Retail	-11.1171	0.0000	-13.0913	0.0000	Stationary
	Farm-gate	-7.1384	0.0000	-9.3296	0.0000	Stationary

The null hypothesis of these tests is that the time series has a unit root or non-stationary. If the absolute value of the ADF or PP is lower than their critical statistics, the null hypothesis of non-stationarity will not be rejected. Critical values for both ADF and PP tests are: -3.486 at 1 percent, -2.886 at 5 percent and -2.5798 at 10 percent.

Source: Research Findings, 2016

4.2.2 Johansen'sCointegration Test: With evidence that the two price series were non-stationary at level, the study proceeded to establish whether the variables were related in the long run using Johansen cointegration test. Selection of the optimum lag length is necessary before test for cointegration can be done because it removes autocorrelation in the series so that the error term becomes white noise (Uchezuba, 2010). It also ensures that the model is correctly specified. Table 4.3 shows the results for optimal lag process according to each criterion. Since two out of three criteria selected three as the optimum lag length, the study adopted three lags.

Table 4.3 Optimum Lag-Length

Lags	Loglik	AIC	SBIC	HQIC
1	367.50425	-6.198349	-6.008446*	-6.121259
2	372.62464	-6.217666	-5.932812	-6.102032
3	381.96895	-6.309810*	-5.930004	-6.155630*
4	384.24228	-6.280039	-5.805282	-6.087315

* Indicates the best lag order selected by the respective information criteria. AIC: Akaike criterion, SBIC: Schwarz Bayesian criterion and HQIC: Hannan-Quinn criterion.

Source: Research Findings, 2016

After estimating the lag length, the next step was to determine the long run relationship between the variables. The results in table 4.4 indicate that there was one cointegrating vector in the price series. At $r = 0$ the trace statistic (28.0786) was higher than its critical value of 15.41 and hence the null hypothesis of no cointegrating equations was rejected. At $r = 1$, the trace statistic (0.3545) was smaller than the critical value of 3.76 and thus the study failed to reject the null hypothesis of at most one cointegrating relationship. This means that there was one cointegrating vector in the model and therefore a long run relationship existed among the two price series.

Table 4.4: Johansen Tests for Cointegration

Trend: constant — Number of obs =117

Sample: 2006m4 - 2015m12 — Lags =3

Maximum Rank r	Eigen Value	Trace Statistic	5% Critical Value
r=0	__	28.0786	15.41
r=1	0.21098	0.3545*	3.76
r=2	0.00303	__	__

The null hypothesis H_0: no cointegration, r denotes the number of cointegrating relationships and * denotes rejection of the null hypothesis at 5 percent significance level.

Source: Research Findings, 2016

The null hypothesis of lack of one cointegrating equation between the variables was rejected at the 5 percent significance level. It was therefore concluded that Kenyan milk markets contain one cointegrating relation. That is the two prices moved together in the long run. Based on the VECM results, a one percent increase in farm-gate prices leads to a 3.14 percent increase in retail price. The value of the elasticity of price transmission is higher than 1 and therefore an imperfect market structure is considered; more specifically oligopoly power is presented meaning that the market power is on the demand side according to Lloyd *et al.,* (2004). This means that retailers have a stronger power than producers.

According to Bor*et al.,* (2013) a 1 percent increase in the raw milk prices increased the retail milk prices by 1.77 percent in the long-run in the Turkish dairy market. Since the processors and the retailers incur costs like processing, packaging, distribution, inventories this figure shows that there is a difference that cannot be explained by the cost formation in the long run. Thus, this result may indicate a significant market power in the milk market.

4.2.3 Short Run Relationship: Given that the two price series were cointegratedthere was need to estimate the speed at which the price series adjust to equilibrium following a shock. A vector error correction model was estimated to assess the short run relationships between the price series. The speed of adjustment to long run equilibrium was 0.2683. This indicates a feedback of 26.83 percent. For adjustment to long run equilibrium to occur, the sign of the coefficient should be negative and statistically significant. The coefficient was negative and statistically significant at one percent significance level. From the results, it is evident that any shock that causes the prices to drift away from long run equilibrium will initiate adjustments to correct 26.83 percent of the deviations back to equilibrium within a month. The estimated VECM equation for the series is presented below;

$$\Delta RP_t = 0.4313 + 0.2014\,\Delta RP(-1) + 0.0615\,\Delta RP(-2) + 0.0711\,\Delta RP(-3) - 0.3171\,\Delta FP(-1) - 0.3189\,\Delta FP(-2) - 0.5037\,\Delta FP(-3) + 0.2683ECT \quad \ldots 4.1$$

Table 4.5: Vector Error Correction Model Results

Independent Variable	Dependent Variable	Coefficient	Std. Error	t-ratio	p-value
ΔRP	Constant	0.4313	0.407722	1.057791	0.2925
	ΔRP_1	0.2014	0.09680	2.0807	0.0398*
	ΔRP_2	0.0615	0.09755	0.6301	0.5300
	ΔRP_3	0.07112	0.09838	0.7229	0.4713
	ΔFP_1	−0.3171	0.41805	−0.7586	0.4497
	ΔFP_2	−0.3189	0.42965	−0.7422	0.4596
	ΔFP_3	−0.5037	0.44617	−1.1290	0.2614
	ECT	−0.2683	0.07133	−3.7612	0.0003**

Note:**Significant at 1 percent, *Significant at 5 percent

Source: Research Findings, 2016

4.2.4: Granger Causality Tests: The presence of a long run relationship may imply that there must beunidirectional Granger causality among the price series (Engle and Granger, 1987). Cointegration alone cannot be used to understand the direction of price transmission and thus causality tests are necessary (FAO, 2003). Granger causality tests do not only confirm cointegration but also show the direction of price transmission between two price series.

Granger causality tests were performed on each market pair and the results are presented in table 4.6. The null hypotheses of no Granger causality were rejected for the two market levels. The results indicate that there was bidirectional causality from farm-gate to retail prices and from retail to farm-gate. This implies that producers cannot adjust their raw milk prices without retailers reacting and similarly retailers cannot adjust prices without worrying of producers adjusting theirs.

Table 4.6: Granger Causality Wald Tests

Price	ΔFP	ΔRP	Prob> chi^2
ΔFP	–	$\chi^2 =$ 14.169	0.000
ΔRP	$\chi^2 =$ 38.374	–	0.000

Note: The null hypothesis is there is no Granger causality.
Source: Research Findings, 2016

These results support a study by Saghaian (2007) who found out that beef price causality in the U.S. markets at different levels of the supply channel are bi-directional, influencing and being influenced by each other at each stage. In their comprehensive study on horticultural marketing in Zimbabwe, Guvheya*et al.*,(1998) investigated farm-wholesale and wholesale-retail price causality. They found that prices flow from wholesale levels in both directions to farmers and retailers. However, the results do not support a study by Goodwin and Holt (1999) who noted that the direction of causality in agricultural supply chains flow from the farm level to the retail level.

4.2.5: Diagnostic Tests: The stability condition of the Johansen model was tested using the companion matrix. The Eigen values are plotted as shown in figure 4.3. The moduli of the companion matrix were all within the unit circle. This implies that the model was correctly specified.

Table 4.7: Eigen Value Stability Condition

Root		Modulus
1.000000		1.000000
0.755587	- 0.397973i	0.853987
0.755587	+ 0.397973i	0.853987
-0.288935	- 0.367831i	0.467743
-0.288935	+ 0.367831i	0.467743
-0.457985		0.457985
0.243823	- 0.284103i	0.374385
0.243823	+ 0.284103i	0.374385

VECM specification imposes 1 unit modulus
Source: Research Findings, 2016

Figure 4.3 shows a plot of the eigen values on a companion matrix. The VECM imposes 1 unit moduli.

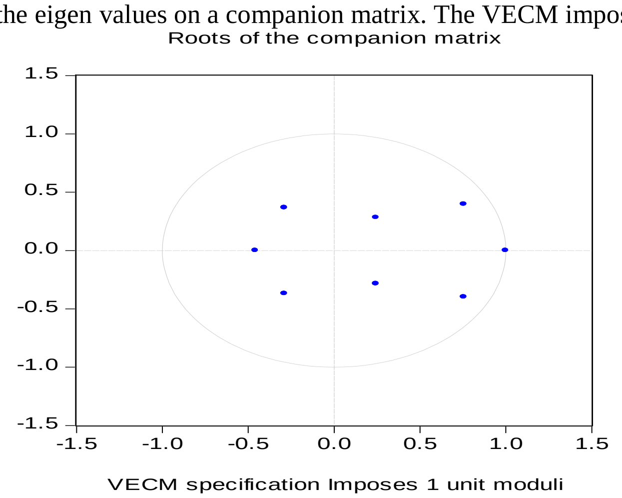


Figure 4.3: Roots of the companion matrix
Source: Research Findings, 2016

The Lagrange multiplier (LM) method results indicated that there is no correlation at lag orders one, two and three. This is presented in table 4.8.

Table 4.8: Lagrange-Multiplier Test

Lags	LM-Stat	Prob
1	3.810838	0.4322
2	6.141867	0.1888
3	4.607214	0.3300

Null Hypothesis: no serial correlation at lag order
Source: Research Findings, 2016

The null hypothesis could not be rejected at 1 percent significance level implying that the two price series were jointly normally distributed. Individually, the results show that the null hypothesis could not be rejected for retail price series at 1 percent but was rejected for farm-gate price series. The results are shown in table 4.9 below.

Table 4.9: Jarque-Bera Test

Price Series	chi^2	Prob> chi^2
ΔRP	23.604	0.00001
ΔFP	1.165	0.55855
ALL	24.769	0.00006

Source: Research Findings, 2016

The results indicate that individually only ΔFP was skewed while ΔRP was not skewed. Overall, the two variables were jointly not skewed with a p value of 0.02208. The results are presented in Table 4.10.

Table 4.10: Skewness Test

Price Series	Skewness	chi^2	Prob> chi^2
ΔRP	0.62417	7.597	0.00585
ΔFP	0.0389	0.030	0.86360
ALL		7.626	0.02208

Source: Research Findings, 2016

Kurtosis tests were carried out on the price series individually and jointly. It is clear from table 4.11 that ΔFP showed presence of kurtosis while ΔRP did not indicate any kurtosis. Jointly, the two price series did not show signs of kurtosis with a p-value of 0.00019.

Table 4.11: Kurtosis Test

Price Series	Kurtosis	chi^2	Prob> chi^2
ΔRP	4.8121	16.007	0.00006
ΔFP	3.4826	1.135	0.28665
ALL		17.143	0.00019

Source: Research Findings, 2016

4.3 Price Transmission in the Kenyan Milk Markets: Table 4.12 and 4.13 present the results of threshold cointegration test between farm-gate and retail market levels.

Table 4.12: Threshold Cointegration Regression Test Results under the TAR Model

		p-value	**ϕ critical values**	
			1 percent	**5 percent**
τ	0.097			
ρ_1	-0.27728** (0.09104)	0.00289		
ρ_2	-0.34764 ** (0.07811)	2.02e-05		
$\Delta\mu_{t-1}$	0.22254 * (0.08950)	0.01436		
$\Delta\mu_{t-2}$	0.24689** (0.09104)	0.00774		
$H_{01}:\rho_1=\rho_2=0$ (ϕ statistic)	13.045**		9.04	6.82
$H_{02}:\rho_1=\rho_2$ (F-statistic)	6.932**	5.003e-05		
AIC	-279.180			
SBIC	-265.369			
LB (4)		0.844		
LB (8)		0.907		
LB (12)		0.663		

Notes: τ is the estimated threshold value, numbers in brackets are the standard errors, ** and * represent statistical significance at 1 and 5 percent respectively, Φ is the threshold cointegration test statistic and F-statistic is the test for symmetric adjustment. Optimal lag length of 2 was selected using SBIC and AIC. The values presented for Ljung-Box (LB) tests are the p values.

Source: Research Findings, 2016

The second objective of the study aimed at determining the nature of price transmission in the Kenyan milk markets for the period 2006 to 2015. Given that the price series in the two market levels were non stationary and the unit root tests showed that the prices were I(1), two related models that is TAR and MTAR were employed in the analysis.Two hypotheses were used to test for cointegration and nature of price adjustment under the TAR and M-TAR models. The first null hypothesis was: $\boldsymbol{H_1}$: $\boldsymbol{\rho_1} = \boldsymbol{\rho_2}$= 0 of no cointegration between the two market levels and the second null hypothesis: $\boldsymbol{H_2}$: $\boldsymbol{\rho_1} = \boldsymbol{\rho_2}$ of symmetric adjustment between market levels.

The optimal threshold value λ minimizing the residuals sums of squares was estimated using Chan's (1993) method. For the TAR model the estimated threshold value was $\hat{\lambda} = 0.097$ and for MTAR was $\hat{\lambda} = 0.074$. The Ljung-Box Q-statistics failed to reject the null hypothesis of no serial correlation at 5 % level of significance.

The results of the TAR model as shown in table 4.12 indicate that the estimated values of ρ_1 (0.27728) and ρ_2 (-0.34764) were both significant at 1 percent level. The negative sign shows that prices converge to equilibrium following both positive and negative shocks.The point estimates of ρ_1 and ρ_2 indicates that, approximately 28 percent of positive deviations and 35 percent of negative deviations from the equilibrium were eliminated within one month. This implies 72 percent and 65 percent of positive and negative discrepancies from the equilibrium respectively would still persist in the following months.

The calculated F value was compared with the critical Φ values in the table provided by Enders and Siklos (2001). From table 4.12, the first null hypothesis $H_{01}:\rho_1=\rho_2=0$ that tests for cointegration was rejected in favour of the alternative since the estimated value of 13.045 was greater than the tabulated Φ statistic critical values of 9.04 and 6.82 at 1 percent and 5 percent significance levels respectively. The rejection of the null hypothesis leads to the conclusion that ρ_1 and ρ_2 are significantly different from zero and thus cointegration exists among the two prices.

Having rejected the first null hypothesis, the study proceeded to test the second null hypothesis. The standard F test was used to test the second null hypothesis of $H_{02}:\rho_1=\rho_2$ for price symmetry. The results indicate that the null hypothesis was rejected at 1 percent and 5 percent thus showing no evidence of symmetry in the size of positive and negative deviations. The results indicate that $\rho_1 \neq \rho_2$, that is they were significantly different from each other. The study concluded that there was asymmetry in the magnitude of adjustment of both positive and negative shocks in the market levels according to the TAR model.

Having estimated the results for TAR model it was necessary to test for cointegration and nature of price transmission using the MTAR model. The MTAR model measures whether positive and negative shocks exhibit different speeds of adjustment towards long run equilibrium. A test for cointegration was first carried out before a test for price symmetry was done. Table 4.13 shows the results of MTAR cointegration and symmetric adjustment process.

The results indicate that the point estimates are ρ_1= -0.14629 and ρ_2= -0.36334. It implies that if there is a shock, 14.63 percent of positive deviations and 36.33 percent of negative deviations would be eliminated within a month. It therefore means that 85.37 percent of positive deviations and 63.67 percent of the negative deviations would persist in the following months. Both point estimates had negative values but only ρ_2 estimate was significant.

The results of threshold cointegration show that the null hypothesis of no threshold cointegration was rejected at both1 percent and 5 percent levels of significance since the computed value, 14.487 was greater than the critical values of 10.35 and 7.95 at 1 percent and 5 percent levels of significance respectively. It was then concluded that there existed a long run relationship among the price series.

Given that the price series were cointegrated, the null hypothesis of symmetric adjustment $H_{02} : \rho_1 = \rho_2$ was tested using a standard F-distribution. The results indicate that $\rho_1 \neq \rho_2$ that is they were significantly different from each other. The null of symmetric adjustment was thus rejected at both 1 and 5 percent levels of significance given that the sample value of F was 7.662 with a p-value of 1.689e-05. The Ljung-Box Q-statistics failed to reject the null hypothesis of no serial correlation at 5% level of significance.

M-TAR model result thus suggested that value of positive deviation was different from the value of negative deviation among the price series. The study concluded that there was asymmetry in the speed of adjustment of both positive and negative shocks in the market levels. This means that positive and negative discrepancies tend to revert to long run equilibrium at different speed.

Kinnucan and Forker (1987) studied price relationship between farm-gate and retail levels for milk, butter, cheese and ice cream in the US market using distributed lag model and found positive asymmetries among the price series. Similar results are also obtained byChavas and Mehta (2002) who found asymmetric adjustments for wholesale-retail price dynamics in the US butter market by using ECM.

Aguiar and Santana, (2002) studied farm-gate to retail price relationships in the Brazilian market using monthly data for fluid milk and dry milk and found that there existed positive asymmetry. Like Chavas and Mehta, (2002) they used the ECM. Reziti (2014) used monthly milk prices in the Greece market to analyze producer to retailer price relationships. Using the ECM, the results indicated that there existed asymmetry in the milk market.

Table 4.13: Threshold Cointegration Test Results under the MTAR Model

		P-value	**Φ critical values**	
			1 percent	**5 percent**
τ	0.074			
ρ_1	-0.14629 (0.12119)	0.22991		
ρ_2	-0.36334** (0.06782)	4.5e-07		
$\Delta\mu_{t-1}$	0.20558* (0.08891)	0.02257		
$\Delta\mu_{t-2}$	0.24247** (0.09014)	0.00823		
$H_{01}: \rho_1 = \rho_2 = 0$ (ϕ statistic)	14.487**		10.35	7.95
$H_{02}: \rho_1 = \rho_2$ (F-statistic)	7.662**	1.689e-05		
AIC	-281.580			
SBIC	-267.770			
LB (4)		0.801		
LB (8)		0.790		
LB (12)		0.467		

Notes: τ is the estimated threshold value, numbers in brackets are the standard errors, ** and * represent statistical significance at 1 and 5 percent respectively, Φ is the threshold cointegration test statistic and F-statistic is the test for symmetric adjustment. Optimal lag length of 2 was selected using SBIC and AIC. The values presented for Ljung-Box (LB) tests are the p values.

Source: Research Findings, 2016

Serra and Goodwin (2003) found that the farm-gate to retail price relationship in the Spanish dairy sector was asymmetric. The study considered milk, cheese and cream caramel using TECM. The above results are also support a study by Capps and Sherwell (2007) who found asymmetric price transmission among farm-gate and retail levels in the USA milk market using ECM. Abdulai (2002)also found asymmetric price transmission between the producer and retail levels in Swiss pork market. This shows that increases in producer prices that lead to declines in marketing margins are passed on more quickly to retail prices than decreases in producer prices that result in increases in the marketing margins. A study by Goodwin and Harper (2000) on price adjustments in the US pork sector also confirmed asymmetries in price transmission in the sector.

The findings of this study also support the fact that most agricultural product supply chains are cointegrated and characterized by asymmetric adjustments as shown by findings of Acquah *et al.*,(2010) on a study of price transmission between retail and wholesale prices of maize in Ghana. They found out that the retail and wholesale prices were cointegrated with threshold asymmetric adjustment.

Stewart and Blayney, (2011) analyzed producer-retailer price relationships in the USA dairy sector using milk and cheese and found that there exist positive asymmetry in the sector. The models used were ECM, TECM and STEM. Kharin, (2015)analyzed farm-gate-retail price transmission in the Russian milk market using monthly data. The study employed ADL model and the results indicated asymmetric adjustment.

4.4Model Selection: Based on the results, both the TAR and M-TAR models suggest asymmetric adjustment mechanism for the series. The next step is to ascertain whether adjustment follows a TAR or M-TAR process. The study used both AIC and SBIC criteria in model selection. Both criteria selected MTAR model over the TAR model because their values are lower in MTAR model (-281.580 and -267.770 for AIC and SBIC respectively) compared to the TAR model (-279.180 and -265.369 for AIC and SBIC respectively).

The selection of MTAR over TAR as the best fit model is supported by Enders and Siklos, (2001). Also Gauthier and Zapata (2001) and Frey and Manera (2005) support the argument that MTAR has a higher power for detecting asymmetry compared to TAR.

5.1 Conclusion: Recent studies on price transmission in the food marketing chain have suggested that middlemen use market power to pass on input price increases to consumers more rapidly and probably more completely, than input price reductions (Bor*et al*., 2014). This study employed recent statistical techniques to examine the long-run and short-run relationship as well as nature of price transmission between producer (farm-gate) and retail prices, giving special attention to the time series properties of the price data.

Using milk prices data over the 2006-2015 sample period, both the threshold autoregressive (TAR) and momentum-threshold autoregressive (M-TAR) models provide strong and clear evidence supporting asymmetric pricing behavior. The results of this paper support the view that retailers exercise market power in Kenyan milk market as evidenced by asymmetric price responses. More specifically, it was found that there exists a positive price asymmetry in farm-gate-retail price transmission in the Kenyan milk market and that such retail prices adjust more quickly to raw milk price increases than to its decreases. This, in turn, implies welfare losses to the consumers.

Johansen's cointegration test results indicate that prices in two market levels converge in the long run and thus, the first null hypothesis that short run and long run price relationships do not exist in the Kenyan milk supply chain was rejected at 5 percent significance level. The VECM captured the short run price relationship and also confirmed convergence of the two price series. The correction back to equilibrium showed that 26.83 percent of the deviations were being corrected in a month. The sign of the ECT coefficient was negative and significant which further confirms that the prices had a long run relationship.

The cointegration results imply a significant market power. There are two main reasons for such market power that are not only correlated, but also trigger each other. First, milk is a storable product traded in concentrated markets and the results indicate that there is a larger degree of elasticity of transmission for price increase. The main cause of this asymmetry lies in the asymmetric relations shaping the formation of the production chain. Producers keep their raw milk in the cooling tanks, where it stays fresh for only a few days before collection by the processor. Therefore, the producers are forced to work under contracts and, inevitably, have little bargaining power over the processors. Nevertheless, after the processing stage the milk can stay fresh for several months on the shelves. Second, the gradual integration of food markets makes it difficult for average producer of raw milk to enter goods and input markets and so they will be faced with price risk (Bor*et al.*, 2014).

In order to overcome these risks and guarantee minimum revenue, they are forced to enter negotiations including contracts with private firms in the absence of government intervention, where such firms supply credit, inputs, and the know-how to the farmers as well as guaranteed price. By entering such contracts, private firms directly or indirectly control the production process by manipulating the standards of production, production quantity, quality, resulting in the farmers' loss of sovereignty over production.

Granger causality tests indicated that there was bidirectional causality this is because farm-gate prices Granger caused Retail prices and farm-gate prices Granger caused retail prices at 1 percent level of significance. This implies producers will not adjust their prices without worrying about reaction from retailers and retailers will not adjust their prices without worrying of producers. The existence of bi-directional Granger causality implies that information flow is optimal.

Both TAR and MTAR models rejected the first and second null hypotheses of no cointegration and symmetric price transmission respectively. This showed that there existed a long run relationship between the two price series and the nature of price transmission was asymmetric. Under the TAR model, the magnitude of the distance from equilibrium differs between positive and negative shocks and under the MTAR model, there was asymmetry in the speed of adjustment of correcting positive and negative deviations after a shock that is positive and negative deviations are corrected back to the equilibrium at different speeds.

The asymmetric price transmission in the two market levels may be the reason why price of pasteurized milk remained high despite the increase in production. Hence, an increase in production should be accompanied by an efficient marketing system so that the commodity reaches the final consumer at an affordable price.

5.2 Recommendations: Despite the Granger causality tests reporting bidirectional causality, there exist asymmetries in the Kenyan milk supply chain as evidenced by the TAR and MTAR results. Based on the findings, the study recommends that the KBD be strengthened so as to improve dairy development and promotional activities. Infrastructure development should be at the core of government policies so as to facilitate transportation and distribution of milk and milk products.

The dairy cooperatives have in the past contributed significantly to the development of smallholder milk marketing and provided farm inputs and services at relatively low cost. However, cooperatives have lost out since liberalization, owing to many factors that include competition, inability to adapt to change, poor payouts, poor management and corruption. There is need to revive cooperatives and make them more relevant to members' needs especially improving marketing of raw milk and increasing the bargaining power of the producers since they are in most cases exploited by processors.

At the market level, the challenges of quality and safety of milk, owing to the high proportion of raw milk channeled through the market need to be addressed. This will assure producers of a good price for their product as it meets the quality standards and ensure efficiency in price adjustments in the sector.

The quality and availability of dairy information continues to be a challenge. There is need for clearer policy and legal instruments. Despite the many years and capital invested in developing and formulating these instruments and the government's declared commitment to reforming the regulatory environment little has been done.

5.3 Suggestions for Further Research: This study was limited to study of price transmission along the Kenyan milk supply chain with consideration at only two levels that is the farm-gate (producer) and the retail levels. A study that incorporates wholesale prices should be conducted so as to bring a clear picture of the milk supply chain.

The study was limited to vertical price transmission. Based on this there is need to carry out a study on horizontal price transmission so as to know the price formations in the milk markets. There is need to also incorporate a study that will compare price formations before and after decontrol of the sector.

The study focused on raw milk and pasteurized milk only. Given the availability of data of other milk products such as yoghurt, cheese, ghee and butter, there is need to do a study that captures the nature of price relationships between the raw milk and these products.Given the integration of markets due to regional trade, the study recommends a cross country analysis of price transmission in the milk sector for instance between the East African countries or from the world to local markets.

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Appendix 1: Empirical Studies of Vertical Price Transmission on Dairy Products

Author(s)	Year	Journal	Relationship	Product	Country	Frequency	Result	Model
Kinnucan, Forker	1987	AJAE	Pf ↔Pr	Milk, Butter, Cheese, Ice Cream	USA	Monthly	Asymmetry	DLM
Aguiar, Santana	2002	AG	Pf ↔Pr	Fluid milk,dry milk	Brazil	Monthly	Asymmetry	ECM
Serra, Goodwin	2003	AE	Pf ↔Pr	Milk, Cheese, Cream Caramel	Spain	Monthly	Asymmetry	TECM
Chavas, Mehta	2004	AJAE	Pw ↔Pr	Butter	USA	Monthly	Asymmetry	ECM
Jensen, Møller	2007	WP	Pf ↔ Pw ↔Pr	Milk	Denmark	Monthly	Asymmetry	ECM
Capps, Sherwell	2007	AB	Pf ↔Pr	Milk	USA	Monthly	Asymmetry	ECM
Baumgartner *et al*.	2009	WP	Pf ↔Pr	Milk, Butter, Cheese	Austria	Monthly	Asymmetry	TVECM
European Commission	2009	RP	Pf ↔Pr	Milk, Butter, Cheese and other	EU-27	Monthly	Asymmetry	DLM

Stewart, Blayney	2011	ARE	Pf ↔Pr	Milk, Cheese	USA	Monthly	Asymmetry	ECM/TECM /STECM
Holm *et. al*	2012	AE	Pr ↔Pw	Milk, Butter	Germany	Weekly	Asymmetry	TECM
Reziti	2014	EB	Pf ↔Pr	Milk	Greece	Monthly	Asymmetry	ECM
Bor*et.al*	2014	NM	Pf ↔Pr	Milk	Turkey	Monthly	Asymmetry	ECM
Kharin	2015	AEs	Pf ↔Pr	Milk	Russia	Monthly	Asymmetry	ADL

Note: AJAE: American Journal of AgriculturalEconomics; AE: Applied Economics; ARE: Agricultural and Resource Economics; AEs: Agricultural Economics, WP: Working Paper; RP: Report; SEC: Southwestern Economic Review, EB: Economics and Business, ADL: Autoregressive Distributed Lag, AG:Agribusiness
Farm gate Price (Pf); Wholesale Price (Pw); Retail Price (Pr);
Distributed Lag Model (DLM); Threshold Vector Error Correction Model (TVECM); Smooth Transition Error Correction Model (STECM)

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