Draft November 2008

The Role of Asymmetric Price Transmission and Structural Breaks in the Relationship between Costa Rican Markets of Livestock Cattle, Beef and Milk

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Contributed Paper prepared for presentation at the International Association of Agricultural Economists Conference, Beijing, China, August 16-22, 2009

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Abstract

The research analyzes the price transmission among the Costa Rican markets of cattle, beef and milk, accounting for asymmetric behavior and structural breaks. Monthly price data covering the first month of 1998 to the fourth month of 2008 were used. Price transmission between each market pair was found. The Price adjustment is consistent at 1% of significant with the behaviour expected. Cattle prices adjust in the milk - cattle relationship, beef meat prices adjust in the cattle - beef meat relation and in the milk - beef meat relation. This finding supports the statement regarding the leading position of "Dos Pinos" as the main player in the market. The results of the asymmetric analysis are not as expected. The coefficients of both adjustments (positive and negative) are not significantly different. The equations allowing for structural break affects the estimates: first after the break the elasticities became higher than 1, second there is more evidence of cointegration and third the adjustment coefficients are significant only when a change in the long run is allowed.

Keywords— **asymmetric prices transmission, structural breaks, livestock, beef, milk, Costa Rica.**

JEL: C32, Q11, Q13

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1. Introduction

Researchers have classified the prices transmission (PT) according to the type of link maintained by the markets. In first place the spatial PT that takes place between two markets where the characteristics of the products are close to be the same, but are separated by transportation costs. In second place the vertical PT that corresponds to the relationship between two markets from the same production chain (von Cramon-Taubadel and Meyer, 2004). However there is another type of relation, which is associated to spatial PT, but in this case the relationship includes two or more joint products produced in a single production process (i.e.: soybean oil and soybean meal, wool and mutton) (Gardner, 1987).

It is possible to find an example of a pair of join products in the relation of the beef and milk markets in Costa Rica. In many countries these goods are produced in largely separate chains. Nevertheless, in Costa Rica roughly 27% of the farms use cattle to produce both, meat and milk. They are called the double intention farms (Holmann et al., 2007).

In order to do appropriate analyses of these join products, it is essential to take into account the specific characteristics of their relation. First, the biological features of the livestock cattle production affect the decisions of farmers, for example to withhold cows for producing milk instead of slaughtering them. This behavior might be asymmetric i.e. farmers may react differently if the cost of keeping a cow for milk production rises than if it declines. Beef production can be increased quickly by slaughtering. Whereas it takes more time for a calf to become a lactating cow. The asymmetric behavior inside the beef and milk markets has been carried out in previous investigations of PT. For example, Zheng et al. (2008) have found asymmetry in the beef sector of the US in the farm-wholesale and the wholesale-retail price relationship, but not in the production chain of milk.

Another important aspect is the alterations along a period of time in the relationship between the variables. For example changes in government legislations, in the economic condition and in the international situation of the products can provoke structural changes that modify the link between the related variables. If it is not accounted for can lead to biased estimation results and thus misleading conclusions (Zhang et al., 2006).

The principal objective of this research is to analyze the price transmission between Costa Rican markets of cattle, beef and milk, accounting for asymmetric behavior and structural breaks in the long run equilibrium. The paper is organized in six sections. Section two presents the relevant structure of the livestock, beef and milk markets and their interrelationships. Section three describes the methodology adopted. Section four provides a short description of the data its sources. Section five presents the empirical results and their implications. Finally section six contains some concluding remarks.

2. The Case of Costa Rica

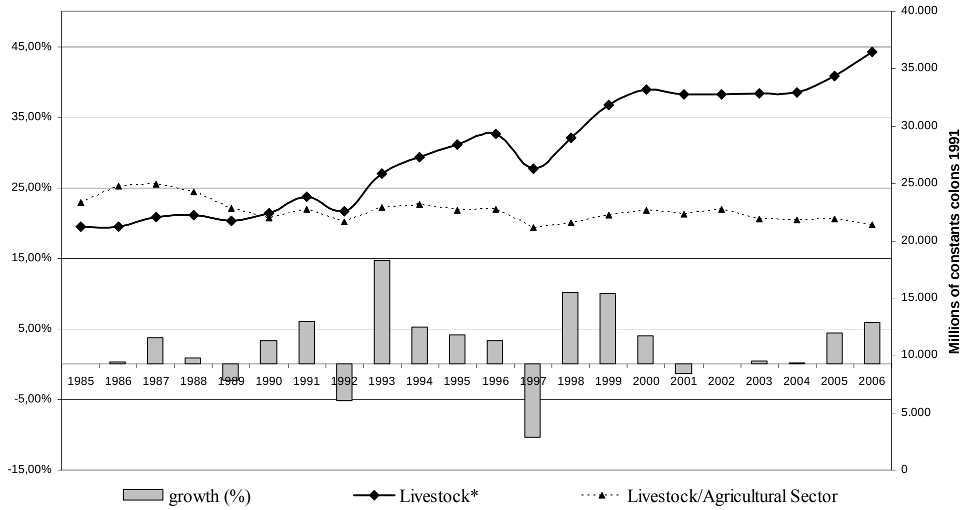
2.1 The Livestock Sector

The livestock sector has been an important part of historical and economic development in Costa Rica over the last 250 years (Quirós, 2006). This evolution has converted the livestock sector in the use of the soil, before the natural protected resources, that occupies the biggest proportion of land (Bertsch, 2006), generating significant environmental externalities. In addition, livestock production employs 12% of the agricultural workforce the majority or which works in cattle breeding.

Livestock has represented in the last three decades around the 22% (Figure 1) of the agricultural sector. Nevertheless in the aggregate this industry has lost importance. However, the dairy sector has experienced a dynamic growth of 3.5% between 1996 and 2006 (CPL, 2007). Therefore beef cattle production is the one that has declined, on average 0.1% since the 1980s (Corfoga, 2005).

In Costa Rica the dairy and the beef sectors cannot be regarded independently because a significant part of producers are classified as double intention farms, which work in both activities. Around of 22% of the animals belong to the double intention farms whereas 65% belong to beef and 13% to dairy farms (CORFOGA, 2001). According to the Census 2000 23% of the farms are dedicated to the double intention production (CORFOGA, 2001). It is worth to note that the double intention farms used principally Cebu animals to produce milk and beef cattle, being this kind of animal the most important in the beef farm´s herds as well (CORFOGA; 2001a).

Figure 1
Added value of livestock



Source: Date MAG 2000, 2005, 2006

2.2 The Beef Chain and the Meat Sector

Meat represents an important component in the traditional Costa Rican diet. According to a study performed by Corfoga in 2001, 53% of the population earning lower wages (less than 216 USD/month) and 67% of the class of highest incomes (more than 900 USD/month), consumed beef meat at least twice per week. Despite of that consumption per capita is declining over the past 20 years. It was increasingly substituted by other meat products, such as poultry and pork[1]. It is worth to note that the consumers do not have the same preference for all the type of cuts. They prefer the beef ground (26.01% of the families), the steak of first quality (24.3%) and the loin (11.46%) (CORFOGA, 2003).

Related to the beef cattle chain, there are two principal options where the farmer can sell beef cattle. The most attended option is the auction, which are important for cattleman because it is easier to discover the tendencies of the prices. The other one is the industry, which is responsible for the slaughter, deboning and packing of the cattle. There are three principal enterprises, which slaughter between 70 to 80% of the livestock (Holmann et al., 2007).

[1] Annex 1, Figure 4.

2.3 Milk Cattle Chain and Milk Sector

The demand has been experiencing a very remarkable increase over the last 50 years, more than the rest of Central America. In fact the consumption per capita of milk is grater than 200 liter per year (FAO, 2006).

The milk producers have three commercialisation channels: industrial, informal and self-consumption. Between 54% and 61% of the national production flows through the industrial channel. It is dominated by Cooperatives, which are vertically integrated.

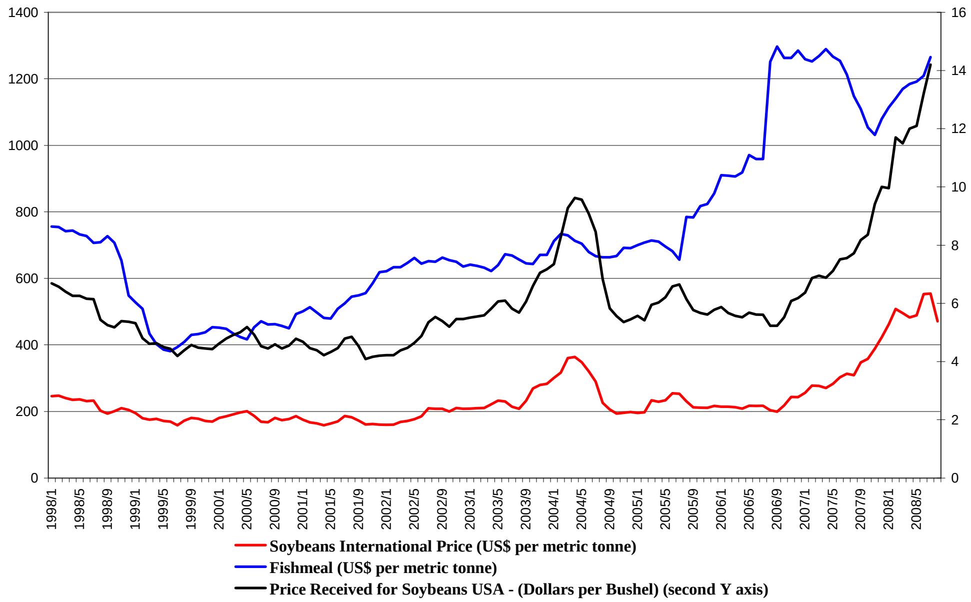
The principal cooperative is Dos Pinos, which produces 85% of the industrial milk product. Dos Pinos influences the sector in a strong way. Primarily, its huge share of the market has made this enterprise the leader of the milk prices. Secondly, it is established in the contract with his associates a compromise to buy the totality of their production. The arrangement include that the producer must sell whole the milk to the Dos Pinos. One of the consequences is that when there is an adjustment in prices, for example for increase in the cost of the factors of production, it must been enough to compensate the increase in cost, but not too much to lose demand (Fallas, 2007) (Fallas, 2008) (Leiton, 2006) (Barquero, 2001).

2.4 Important Changes in the Milk and Beef Markets

In the cases of beef and livestock, there are two important international shocks which have changed the behavior of the markets. First, the demand of beef increased from 2004 to 2005, when China market stopped the import of USA products and import beef from others markets, raising the international prices (Leiton, 2005) (Rojas, 2005). Second the increment in the international prices of the soya bean, fish meal, and others products which are used in the diet of the animals. Despite the fact that in Costa Rica the alimentation of the herd is based in the grass consumption, maintain a constant supply of quality pasture is impossible. Hence the farmers resort to the supplementary alimentation. Then the increments in the prices of these products affect the cost of the livestock producers, thus the prices. Between 2002 and 2004 a strong growth of supplies prices caused an increase of about 30% in raw materials prices (Barquero, 2007).The Figure 2 points out the tendency of international prices, which is growing around 2005/6 to 2006/6. This situation also affects the milk market.

In addition, there is other significant change in the milk market. After 2002 the Dos Pinos has sold the milk fluid under the price to cover the productions costs. Since 2002 the company policies have been modified and the price adjustments are according with the production cost (Leitón, 2002). Therefore, it is observable a positive tendency in the prices (Figure 2).

Figure 2
Prices of the feed products



Source: FMI and USDA

2.5. Hypothesis:

Given the characteristics of the three markets, we derive the following hypotheses and expectations. Since the price of milk is principally determined by Dos Pinos, we expected that milk prices will not adjust to correct any deviations to any of the two long run equilibrium, (milk-livestock and milk–beef).

Furthermore, the livestock price is expected to adjust to changes in the milk prices, because the influence of the double intention farms over the supply of cattle to slaughter when the opportunity costs of keeping a cow are change by milk price changes. Moreover, the meat price would adjust to changes in the livestock price when the quantities of beef cattle to slaughter alter the supply of beef.

We also expected APT in the adjustment to the long run equilibrium. In the milk-livestock relationship we expect that when the difference from the long run equilibrium is positive, price of livestock would adjust more rapidly than when it is negative. That is because it is easier to send a cow to the slaughter than to increment the herd to produce milk, so it is reasonable to expect faster adjustment in case of a disincentive in the production of milk. The livestock-beef relation could be affected by the market power; we expect that the large slaughter firms would adjust the beef price more rapidly to livestock price increases than decreases.

3. Methodology

Primary it is used the Augmented *Dickey-Fuller* (ADF) to test the presences of unit roots (Kwiatkowski et al., 1992). The changes happened during the 2002 and 2005-2006 are a sign of the possible break in the behavior of the variable in the long run. Thereby it is used the UR test accounting for structural breaks (Saikkonen and Lütkepohl, 2002). The break point is selected following the Lanne, Lütkepohl & Saikonen (2003) recommendation.

In the cases when the variables are not stationary, cointegration methods are used to test the existence of a not spurious long run equilibrium relation between them (Kirchgässner and Wolters, 2007). Before to applied the cointegration techniques, and once determined the order of the series, it is calculated the long run equilibrium using the following equation:

$$y_t = \beta_0 + \beta_1 x_t + \lambda t + \mu_t \qquad (1)$$

Where y_t is the dependent variable x_t the independent variable (both correspondent to the log of the prices), t the trend which is included just when it is significant at 5% level, μ the error term, and the rest are unknown coefficients.

In some cases the long run equilibrium is holding over some period of time, and then shifting to a new long run relationship. The omission of this situation might provoke bias in the results. In order to find evidences of structural breaks, it is employed the CUSUM and CUSUM Square test to analyze the stability of the equation[2].

Once the period of the possible break is located, it is applied the model suggested by Gregory and Hansen (1996) which considered the idea of cointegration allowing structural breaks. In this context it is defined:

$$\psi_{t\tau} = \begin{cases} 0 & if \quad \tau \le [n\tau], \\ 1 & if \quad \tau > [n\tau] \end{cases}$$

Where the parameter $\tau \in (0,1)$ denotes the timing of the change point, and [ ] denotes integer part. There are three possible long run equilibrium equations:

Model II. With level shift: $y_t = \beta_0^1 + \beta_0^2 \psi_{t\tau} + \beta_1 x_t + \mu_t$ (2a)

Model III. With level shift and trend: $y_t = \beta_0^1 + \beta_0^2 \psi_{t\tau} + \beta_1 x_t + \delta t + \mu_t$ (2b)

Model IV. Regime Shift: $y_t = \beta_0^1 + \beta_0^2 \psi_{t\tau} + \beta_1^1 x_t + \beta_1^2 \psi_{t\tau} x_t + \delta t + \mu_t$ (2c)

[2] Annex 2

Where β_0^1 represent the intercept before the shift and β_0^2 represent the change in the intercept at the time of the shift. β_1^1 denotes the cointegration slope coefficients before the regime shift, and β_1^2 denote the change in the slope.

In view of the τ is deduced a priori (using the stability analysis), the resulting equilibrium relation can be estimated by ordinary lest squares (OLS) (Gregory and Hansen, 1996). In order to select the model which describes better the long run equilibrium, the LRatio test and the R square test is computed for each model and the long run relation with better adjustment is selected.

Thereafter using the Engle-Granger (1987) and Johansen methodologies, cointegration tests are carried out on the pairs of prices. In the case of Engle-Granger two different tests are used to test the stationarity of the error term (μ), in whose case y and x are cointegrated. First the ADF test with adjusted critical values, and second the the Dickey-Fuller General Least Squares (DF-GLS) are applied. Before that the significant numbers of lag are calculated, computing the final prediction error (FPE), Akaike's information criterion (AIC), Schwarz's Bayesian information criterion (SBIC), and the Hannan and Quinn information criterion (HQIC). After that the Johansen trace test (1995) is computed with the intention of determined the cointegration range of the relation. Here it is included the trend only in those cases when it is significant inside the long run equilibrium.

Until this point it is know if price transmission exist between the markets (milk, beef and livestock) and the cointegration coefficient (β_1). Furthermore, in view of the variables are the logs of the prices, β_1 can be interpreted like an elasticity. It is remained only the short run analysis of the relation. In this point it is applied the Johansen (1995) method to estimate the following Vector Error Correction Model (VECM):

$$\Delta Py_t = \alpha_y ECT + \sum_{j=1}^{n_x} \Gamma_{yj} \Delta Py_{t-j} + \sum_{j=1}^{n_y} \Gamma_{yj} \Delta Px_{t-j} + \sum_{i=1}^{k} \delta_i D_{i,t} + \varepsilon_{yt} \quad (3a)$$

$$\Delta Px_t = \alpha_x ECT + \sum_{j=1}^{m_x} \Phi_{yj} \Delta Py_{t-j} + \sum_{j=1}^{m_y} \Phi_{yj} \Delta Px_{t-j} + \sum_{i=1}^{k} \delta_i D_{i,t} + \varepsilon_{xt} \quad (3b)$$

where the error correction term (ECT) is defined as the error (μ) of the long run equation described in (1) and (2). α_i represents the adjustment of prices on the left hand side to the deviations from this long run equilibrium. Γ_{ij} and Φ_{yj} are the short term parameters associates with lagged price changes, and δ_i are the dummy coefficients. When α_x is significant and α_y is not, any deviation from the long run relationship will cause an adjustment in *Px* but not in *Py*.

Finally, the asymmetric behavior it is tested. There is more than one definition of asymmetric in the price transmission. For the aim of this paper, the interest is the asymmetry in the speed of adjustment toward equilibrium level (Frey and Manera 2005). Granger and Lee (1989) propose a modification to equations (3a) and (3b) where ECT is spitted into positive and negative components, and the difference between the α_i of each of them is tested with a LRatio test.

4. DATA

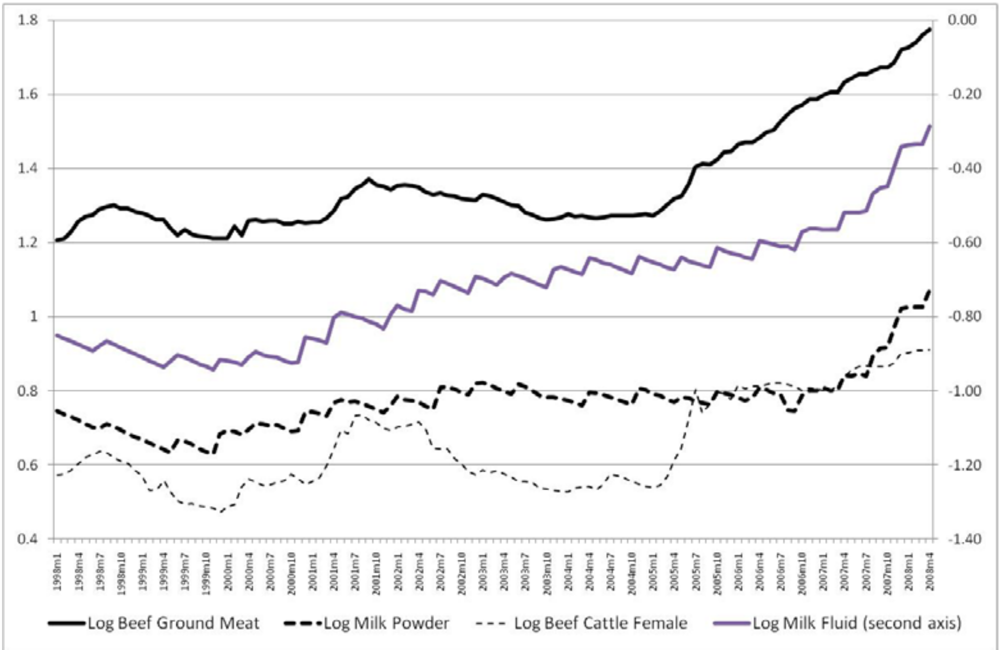
Monthly price data were collected covering the first month of 1998 to the fourth month of 2008. In the milk and meat case, consumer prices were obtained from the National Statistic Institute of Costa Rica (INEC). Beef cattle prices were provided by the National Council of Production.

Beef prices market are represented for ground meat (the most consumed beef product in Costa Rican), and it corresponds to the dollar per kilo price of the product. The Milk corresponds first to the price per liter of the homogenized milk (milk fluid) and second to the price of 400 grams of powder milk. Livestock prices are the producer purchase price of live female cattle for slaughter (carcass price) (Figure 3).

It is worth to note that the behavior of both milk prices is characterized for sharps (Figure 3). These correspond to the Dos Pinos adjustment of the prices, which has been affecting in an important way the performance of the entire market.

For the econometric analysis the prices are used in logarithms. The results were calculated using to the econometric programs JMulti and STATA.

Figure 3
Log of the value in dollars of the Prices
1998/1 until 2008/4



Source: Own elaboration

5. The empirical results

Using the ADF test, we cannot reject the null hypothesis of a unit root at the 10% significance level for any of the three prices (Table 1). The first difference of the fluid milk price is stationary at the 5% of significance when the constant so much as the trend are excluded for the analysis, though in the VAR both of them are statistically significant at the 5% of significant. We also use the UR test which allows for structural breaks. The first difference of the price of beef ground and beef cattle are not I(0). Nevertheless, when the optimum lag number is choosing taking into account the Schwarz Criterion, the beef ground correspond to a I(0) variable. Even so, based on the preponderance of evidence, we consider all four prices as no stationary in the following analysis and difference them once to achieve stationary.

Table 1
Results of Unit Root Tests

Variables (Prices)	Augmented Dickey-Fuller[1]						UR with Structural Break						
	with constant and trend		with constant without trend		without trend and constant		Period	with trend		without trend		lags	
	lags	Value	lags	Value	lags	Value		AIC	Schwarz	AIC	Schwarz	AIC	Schwarz
Log Beef Ground Meat	3	-0,54	3	1,55	3	1,68	2005m7	1,54	3,40	-2,25	-0,71	3	0
Log Beef Cattle Female	3	-2,45	3	-1,17	3	0,36	2005m8	-1,15	-0,68	-2,48	-1,80	3	1
Log Milk Powder	2	-1,02	2	0,90	2	1,60	2002m7	1,41	0,33	-1,23	-1,60	2	0
Log Milk Fluid	2	-1,31	1	1,88	2	-2,33**	2001m4	2,28	1,31	-1,31	-1,85	2	0
First diference													
Log Beef Ground Meat	2	-4,43***	2	-3,68***	3	-2,76***	2005m8	-1,13	-3,19**	-2,40	-4,99***	2	0
Log Beef Cattle Female	2	-4,39***	2	-4,33***	2	-4,31***	2005m8	-1,11	-1,54	-1,89	-2,45	2	0
Log Milk Powder	1	-8,98***	1	-8,67***	1	-8,49***	2002m7	-3,23**	-3,23**	-4,94***	-4,93***	1	1
Log Milk Fluid	1	-9,98***	1	-9,41***	3	-4,68***	2001m4	-4,07***	-4,07***	-5,37***	-5,37***	1	1

***** 1% of significance, ** 5%, * 10%*
[1]Lag length is selected according to the Akaike Info Criterion
Source: Own elaboration

Table 2 shows the results of the long run equilibrium equation. In first place the equations without break present elasticties bigger than 0.6, with the exception of the price of beef meat and milk powder. In contrast, and with the same exception, when in the equation is allowed a structural break, the elasticities before the break do not exceed 0.6.

Since it was mentioned in section 3, the CUSUM and CUSUM Square test was applied to determine the period of the possible structural break (Annex 2). In four of five equations the break corresponds to the first semester of 2005. It is accorded with the period in which the price of soya been in USA present an intensive increase (figure 2). A point worthy of mention is that after the period of break the elasticities are higher than before. In order to identify the influence in the relation of these three markets, the analysis of the price transmission between them and the price of the raw material should be included in a posterior analysis.

The highest elasticity is founded in the relation between the prices of beef ground and beef cattle, almost 2 after the break. It could be related with the higher concentration of the slaughter industry.

Table 2
Long run equation

DEPENDENT	INDEPENDENT	β^1_1	β^1_0	$\beta^1_1+\beta^2_1$	$\beta^1_0+\beta^2_0$	LL	R^2	Periode of Break
Log Beef Ground Meat	Log Beef Cattle Female	0.87***	0.73***			209,49	0,91	
		(18,57)	(29,52)					
Log Beef Ground Meat	Log Milk Powder	0.72***	0.68***			137,20	0,70	
		(0,15)	(7,01)					
Log Beef Ground Meat	Log Milk Fluid	0.80***	1.95***			142,04	0,73	
		(17,94)	(58,66)					
Log Beef Cattle Female	Log Milk Powder	0.48***	0.18***			133,69	0,56	
		(3,34)	(1,84)					
Log Beef Cattle Female	Log Milk Fluid	0.60***	1.09***			135,15	0,57	
		(12,87)	(31,65)					
With a structural break								
Log Beef Ground Meat	Log Beef Cattle Female	0.55***	0.93***	1,82***	0,007***	290,09	0,97	2006m3
		(17,92)	(52,90)	(10,13)	(-8,82)			
Log Beef Ground Meat	Log Milk Powder	0.44***	0.96***	1,13***	0,60***	191,58	0,88	2005m3
		(4,10)	(12,06)	(4,85)	(-3,14)			
Log Beef Ground Meat	Log Milk Fluid	0.17***	1.42**	1,06***	2,13***	212,98	0,91	2005m3
		(3,68)	(37,50)	(11,00)	(13,51)			
Log Beef Cattle Female	Log Milk Powder	0.64***	0.15***		0,39***	193,21	0,83	2005m5
		(7,01)	(2,57)		(13,88)			
Log Beef Cattle Female	Log Milk Fluid	0.49***	1.05***		1,27***	185,31	0,81	2005m5
		(5,39)	(11,62)		(12,18)			

*** 1% of significance, ** 5%, * 10%
Source: Own elaboration

The cointegration results are summarized in table 3. They suggest when the break is not allowed and using the Johansen test, there is not cointegration in the pairs which included the price of milk powder. Even in those cases where the analysis includes the possibility of only one long run equilibrium between the three markets. Nevertheless, there is at least one cointegration vector when it is taking into account a change in the long run relation, only with the exception of beef cattle – milk powder.

In the Engle Granger test the results depend of the numbers of lags. The cases of: beef ground-beef castle, beef ground-milk powder and beef ground-beef castle-milk fluid; do not have any evidence of cointegration without break. However, they present some evidence when the structural change is included. It is worth notice that the last two equations (table 3), which include the three markets at the same time, exhibit signs of cointegration only with the presence of a structural break.

In the equations with break there is not a clear consensus between the tests about the presence of cointegration between beef cattle female and milk (table 3). It is in opposition to the expected behavior, because beef cattle should be the connector between the milk and the beef meat market.

Table 4 displays the results of the VECM. There are included all the pairs of relation, with exception of beef ground- milk powder without break, because all of the indicators in table 3 show there is not cointegration between them.

Table 3
Cointegration Test

DEPENDENT	INDEPENDENT	Johansen Trace Test[1]	Engle Granger Test[2]		
			Significant lags	GLDS Test	ADF
without structural break					
Log Beef Ground Meat	Log Beef Cattle Female	r = 1**	0 - 12	no	no
Log Beef Ground Meat	Log Milk Powder	r = 0	0 - 17	no	no
Log Beef Ground Meat	Log Milk Fluid	r = 1**	0 - 19	no - yes***	no - yes*
Log Beef Cattle Female	Log Milk Powder	r = 0	1 - 16	no - yes**	no
Log Beef Cattle Female	Log Milk Fluid	r = 1**	0 - 12	no-yes***	no - yes*
Log Beef Ground Meat	Log Beef Cattle Female & Log Milk Fluid	r = 1***	0 - 12	no	no
Log Beef Ground Meat	Log Beef Cattle Female & Log Milk Powder	r = 0	0 - 12	no-yes**	no
with structural break					
Log Beef Ground Meat	Log Beef Cattle Female	r = 1***	0 - 3	yes**	yes* - yes**
Log Beef Ground Meat	Log Milk Powder	r = 1***	0 - 13	no - yes**	no
Log Beef Ground Meat	Log Milk Fluid	r = 1***	0 - 13	no - yes*	no
Log Beef Cattle Female	Log Milk Powder	r = 0	0 - 2 - 7	yes* - no - yes*	no
Log Beef Cattle Female	Log Milk Fluid	r = 1**	0 - 2	no	no
Log Beef Ground Meat	Log Beef Cattle Female & Log Milk Fluid	r = 1***	0- 8	no	yes**- no
Log Beef Ground Meat	Log Beef Cattle Female & Log Milk Powder	r = 1***	0-8	no	yes**- no

[1] r = Cointegration range
[2]Yes = Evidence of cointegration. No = no evidence of cointegration. When each lag presents a different solution, there is more than one result for the same test.
*** 1% of significance, ** 5%, * 10%
Source: Own elaboration

Although in the first part of the table 4 the α coefficients are not significant, when the break is included the adjustment coefficients became, as expected, significant and negative. Furthermore, at 1% of significant the directions of the adjustments are as expected (beef cattle prices adjust in the milk-beef cattle relationship, beef meat prices adjust in the beef meat- beef cattle relation and in the milk-beef meat relation). Nerverthenless, at 10% the adjustment coefficients of milk market became significant in four of five relations which include it. Moreover, the last equation shows there is an adjustment so much in beef meat price as in milk powder in respond to a deviation from the equilibrium. It might be indicating the prices of raw products are affecting the cost of breeding a cow, and the Dos Pinos take it into account to determine the milk price. Simultaneously it affects the price of beef cattle and therefore the price of beef meat.

It is worth to notice that in agreement with the autocorrelation indicator (five column table 4), the errors of the VECM equations (ε_{it} in equation 3) do not present signs of autocorrelation. Equally important, the skewness tests (six column table 4) shows that only in the second equations of each pairs there is signs of no normality of the errors.

The LRatio test is used in order to analyse the asymmetry behaviour, however, the null hypothesis that the coefficients of ECT^+ are equal to the coefficients of ECT^- cannot be rejected in any equation.

Table 4
Results of the VECM

Relation	RSquare	Dependent Variable	With Asymmetric			Without Asymmetric		
			α (t test)	Autocorrelation test, Chi2 (probability)	Test of Normality of the errors (skewness), Chi2 (probability)	αposit (t test)	αnegat (t test)	Test αposit=αnegat, Chi2 (probability)
Log Beef Ground Meat - Log Beef Cattle Female	0,360	Log Beef Ground Meat	-0,15	**0,29**	**0,27**	-0,21	-0,01	0,56
			(-0,66)	**(0,59)**	**(0,23)**	(-0,45)	(-0,20)	
		Log Beef Cattle Female	-0,01	**0,12**	**-0,03**	-0,08	0,07	(0,75)
			(-0,17)	**(0,72)**	**(0,88)**	(-1,00)	(0,85)	
Log Beef Ground Meat - Log Milk Fluid	0,328	Log Beef Ground Meat	0,00	**0,90**	0,46	,-0,06*	0,04	3,38
			(-0,17)	**(0,34)**	(0,04)	(-1,74)	(1,48)	
		Log Milk Fluid	0,06***	**0,00**	1,21	0,03	0,081*	(0,18)
			(2,88)	**(0,97)**	(0,00)	(0,54)	(1,84)	
Log Beef Cattle Female- Log Milk Powder	0,254	Log Beef Cattle Female	-0,30	**0,06**	**0,07**	-0,07**	0,00	2,63
			(-1,55)	**(0,81)**	**(0,76)**	(-2,23)	(-0,00)	
		Log Milk Powder	0,02	**1,64**	1,46	0,02	0,02	(0,27)
			(1,09)	**(0,20)**	(0,00)	(0,68)	(0,75)	
Log Beef Cattle Female - Log Milk Fluid	0,246	Log Beef Cattle Female	-0,02	**0,08**	**-0,01**	-0,07**	0,01	4,90
			(-1,25)	**(0,78)**	**(0,96)**	(-2,12)	(0,23)	
		Log Milk Fluid	0,03	**0,09**	1,63	0,07**	0,01	(0,09)
			(1,64)	**(0,77)**	(0,00)	(1,99)	(0,33)	
Log Beef Ground Meat - Log Beef Cattle Female - Log Milk Fluid	0,429	Log Beef Ground Meat	-0,21	**1,01**	**-0,09**	-0,06	0,02	
			(-0,91)	**(0,32)**	**(0,69)**	(-1,28)	(0,40)	3,82
		Log Beef Cattle Female	0,01	**2,72**	**-0,06**	-0,08	0,10	
			(0,13)	**(0,10)**	**(0,79)**	(-0,96)	(1,13)	
		Log Milk Fluid	0,05	**0,22**	1,25	-0,05	0,17*	0,28
			(1,19)	**(0,64)**	(0,00)	(-0,59)	(1,85)	
Log Beef Ground Meat - Log Beef Cattle Female - Log Milk Powder	0,418	Log Beef Ground Meat	-0,21	**0,29**	-0,07	-0,05	0,17	
			(-0,91)	**(0,59)**	**(0,77)**	(-1,28)	(0,36)	1,97
		Log Beef Cattle Female	-0,01	**1,51**	**-0,06**	-0,09	0,88	
			(-0,23)	**(0,22)**	**(0,78)**	(-1,20)	(1,02)	
		Log Milk Powder	0,07*	**1,67**	4,63	0,04	0,10	0,58
			(1,73)	**(0,20)**	(0,00)	(0,62)	(1,22)	
with structural break								
Log Beef Ground Meat - Log Beef Cattle Female	0,403	Log Beef Ground Meat	-0,19**	**0,10**	**0,31**	-0,77	-0,17***	0,82
			(-3,05)	**(0,75)**	**(0,17)**	(-1,03)	(-2,57)	
		Log Beef Cattle Female	-0,01	**0,13**	**0,00**	0,00	-0,03	(0,66)
			(-0,18)	**(0,72)**	**(0,99)**	(0,02)	(-0,23)	
Log Beef Ground Meat - Log Milk Powder	0,375	Log Beef Ground Meat	-0,05***	**3,12**	**0,27**	-0,01	-0,85**	2,80
			(-2,59)	**(0,08)**	**(0,22)**	(0,75)	(-2,37)	
		Log Milk Powder	0,05*	**0,68**	1,13	0,01	0,09	(0,25)
			(1,78)	**(0,41)**	(0,00)	(0,21)	(1,63)	
Log Beef Ground Meat - Log Milk Fluid	0,368	Log Beef Ground Meat	-0,06***	**1,65**	**0,24**	0,00	-0,12***	3,70
			(-2,77)	**(0,20)**	**(0,28)**	(0,02)	(-2,77)	
		Log Milk Fluid	0,07*	**0,11**	1,34	0,02	0,13*	(0,16)
			(1,94)	**(0,74)**	(0,00)	(0,23)	(1,67)	
Log Beef Cattle Female - Log Milk Powder	0,297	Log Beef Cattle Female	-0,10***	**0,35**	**-0,26**	-0,06	-0,16***	2,28
			(-3,17)	**(0,55)**	**(0,25)**	(-1,47)	(-2,99)	
		Log Milk Powder	0,04	**1,97**	1,47	0,02	0,07	(0,32)
			(1,39)	**(0,16)**	(0,00)	(0,57)	(1,38)	
Log Beef Cattle Female - Log Milk Fluid	0,283	Log Beef Cattle Female	-0,08***	**0,73**	**-0,29**	-0,05	-0,13**	1,27
			(-2,83)	**(0,39)**	**(0,19)**	(-1,36)	(-2,55)	
		Log Milk Fluid	0,06**	**0,01**	1,62	0,06	0,07	(0,53)
			(2,06)	**(0,94)**	(0,00)	(1,46)	(1,26)	
Log Beef Ground Meat - Log Beef Cattle Female - Log Milk Fluid	0,461	Log Beef Ground Meat	-0,12***	**1,35**	**-0,03**	-0,12	-0,12*	
			(-2,86)	**(0,25)**	**(0,91)**	(-1,49)	(-1,82)	7,30
		Log Beef Cattle Female	0,06	**2,46**	**-0,98**	0,08	0,05	
			(0,77)	**(0,12)**	**(0,66)**	(0,50)	(0,40)	
		Log Milk Fluid	0,01	**0,27**	1,27	-0,32**	0,25	0,06
			(0,18)	**(0,60)**	(0,00)	(2,14)	(2,14)	
Log Beef Ground Meat - Log Beef Cattle Female - Log Milk Powder	0,450	Log Beef Ground Meat	-0,10***	**0,30**	**-0,02**	-0,12	-0,09*	
			(-2,84)	**(0,59)**	**(0,92)**	(-1,64)	(-1,68)	1,22
		Log Beef Cattle Female	0,02	**1,39**	**-0,05**	0,01	0,30	
			(0,33)	**(0,24)**	**(0,81)**	(0,05)	(0,31)	
		Log Milk Powder	0,11*	**0,62**	1,22	-0,03	0,19**	0,75
			(1,84)	**(0,43)**	(0,00)	(-0,22)	(2,17)	

*** 1% of significance, ** 5%, * 10%
Source: Own elaboration

6. Conclusion

Price transmission between each market pair was found. Nevertheless, in opposition to the expected behavior, the relation between the markets of milk and beef cattle show weak signs of cointegration.

The Price adjustment is consistent at 1% of significant with the behaviour expected. Beef Cattle prices adjust in the milk - beef cattle relationship, beef prices adjust in the beef cattle - beef meat relation and in the milk - beef meat relation. This finding supports the statement regarding the leading position of “Dos Pinos” as the main player in the market. Furthermore, at 10%, for milk market the adjustment coefficients to the long run equilibrium are significant. It might be related with the importance of the raw products prices for the cow breeders.

The results of the asymmetric analysis are not as expected. The coefficients of both adjustments, i.e., to positive and to negative deviations from the long-run relation, are not significantly different.

The equations allowing for structural break affects the estimates. First after the break the elasticities became higher than 1. Second there is more evidence of cointegration. Third the adjustment coefficients are significant only when a change in the long run is allowed.

In order to achieve further insights into the analysed relationships, the livestock prices from auctions might be included. Such prices better reflect the behaviour of small farmers, which account for a large number of double purpose farms, however, they were not available for the whole period analysed at the moment of this research.

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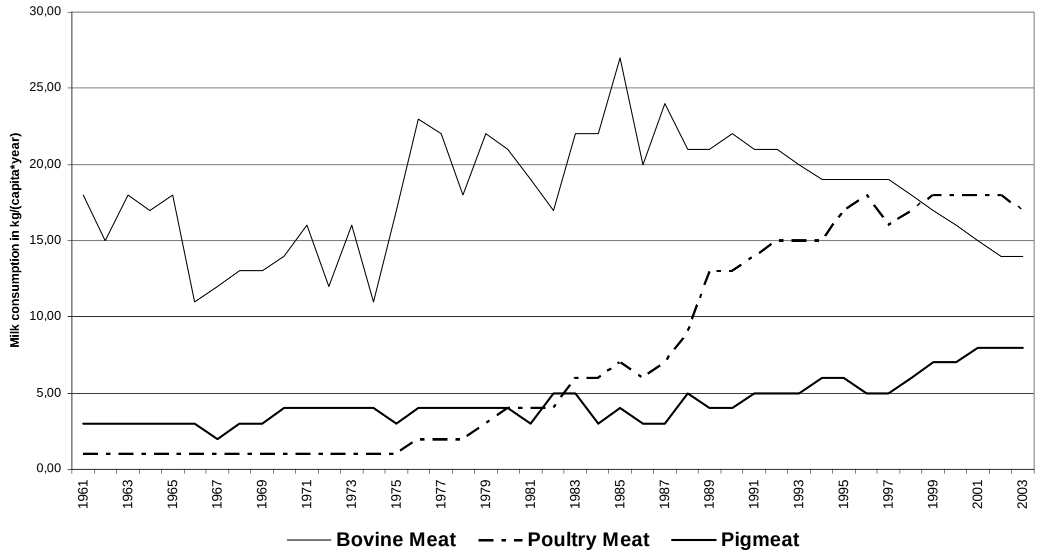
Annex 1

Figure 4
Consumption of the principal meat products



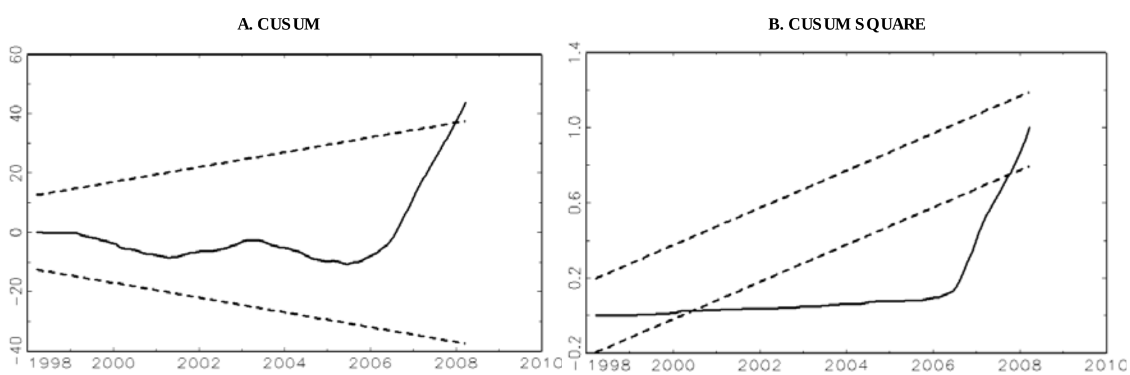
Source: FAO STADT, consumption data

Annex 2

Stability analysis of the long run equation: Cusum and Cusum Square

Figure 5

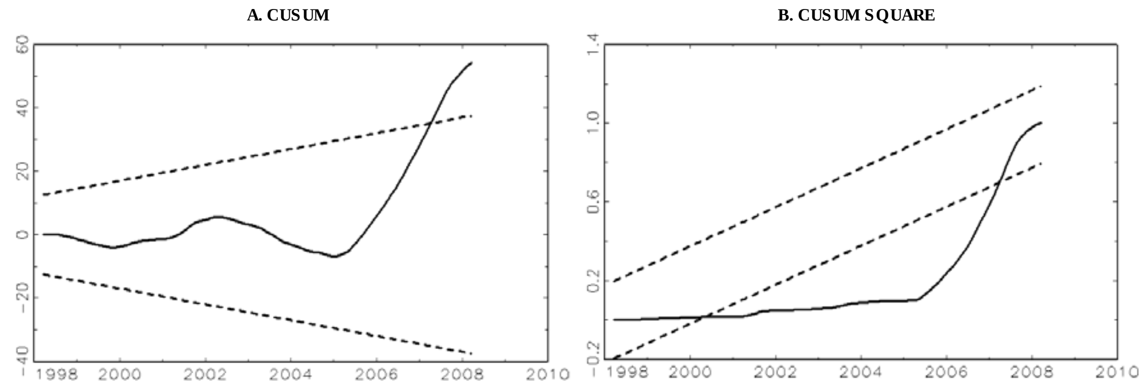
Log Beef Ground Meat and Log Beef Cattle Female



It has been calculated using the JMulti software.
Source: Own elaboration

Figure 6

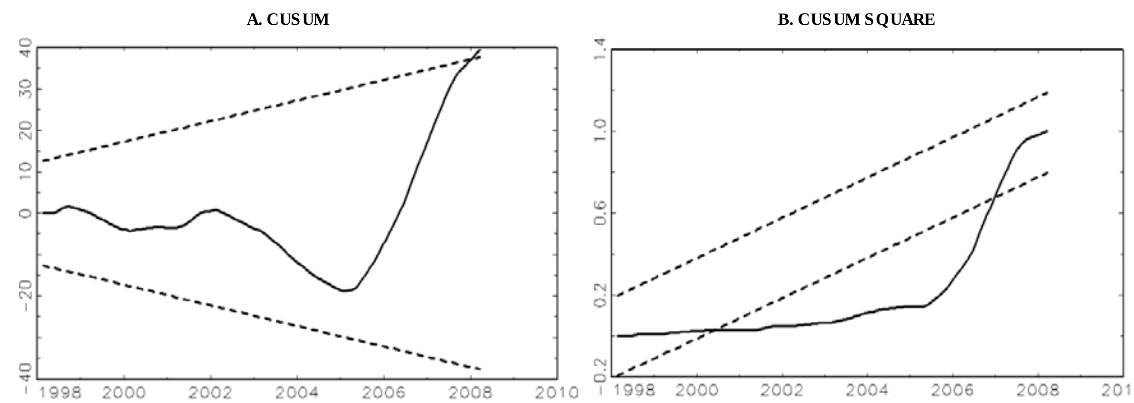
Log Beef Ground Meat and Log Milk Powder



It has been calculated using the JMulti software.
Source: Own elaboration

Figure 7

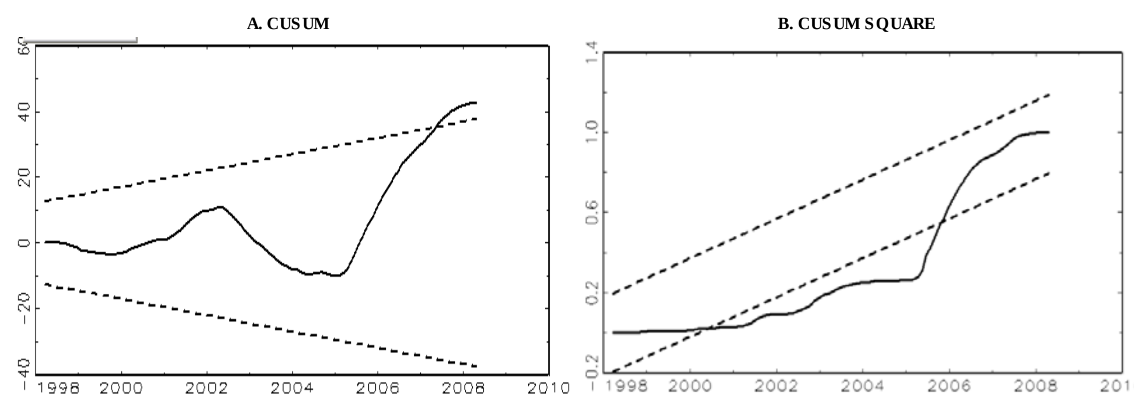
Log Beef Ground Meat and Log Milk Fluid



It has been calculated using the JMulti software.
Source: Own elaboration

Figure 8

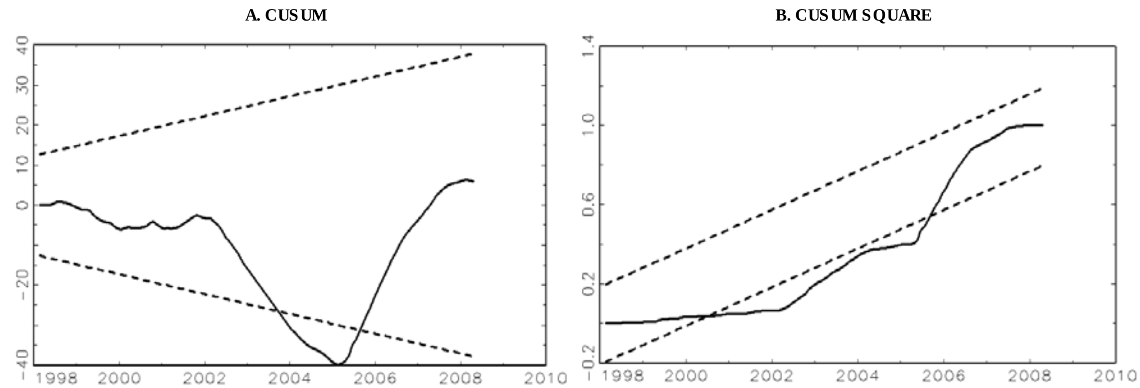
Log Beef Cattle Female and Log Milk Powder



It has been calculated using the JMulti software.
Source: Own elaboration

Figure 9

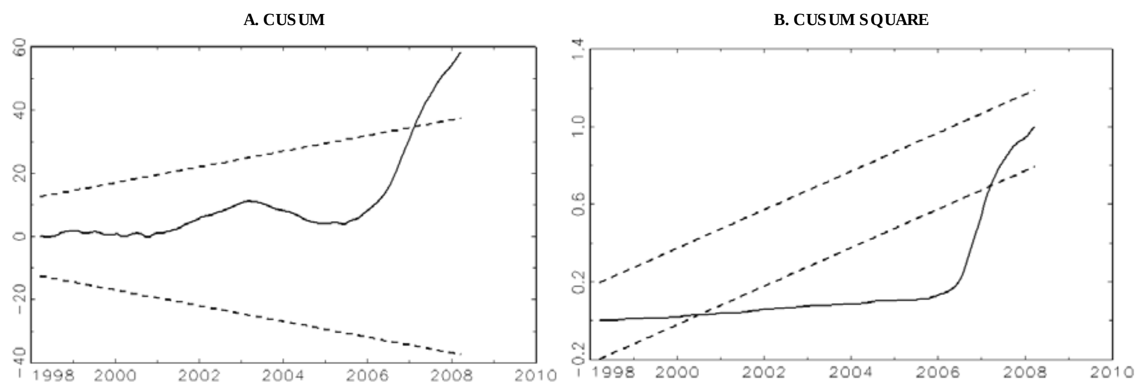
Log Beef Cattle Female and Log Milk Fluid



It has been calculated using the JMulti software.
Source: Own elaboration

Figure 10

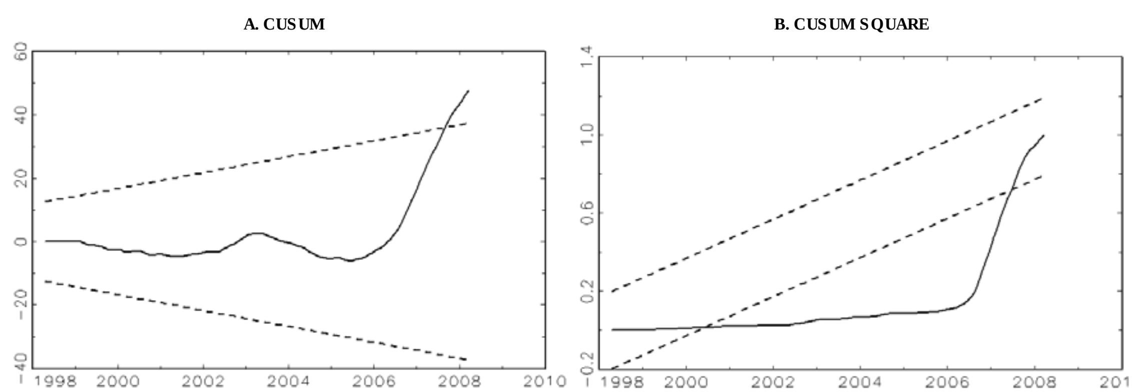
Log Beef Ground Meat, Log Beef Cattle Female and Log Milk Fluid



It has been calculated using the JMulti software.
Source: Own elaboration

Figure 11

Log Beef Ground Meat, Log Beef Cattle Female and Log Milk Powder



It has been calculated using the JMulti software.
Source: Own elaboration