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An Application of the Two-Regime Threshold Vector Error Correction Model to Analyze Asymmetric Price Transmission of Milk in Zanjan Province of Iran

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Abstract

In this paper asymmetric price transmission mechanism and nonlinear adjustment between producer and retail prices of milk were examined in Zanjan Province of Iran. For this purpose, a Two-Regime Threshold Vector Error Correction Model (TVECM) and a Sup-LM Test developed by Hansen and Seo (2002) were employed for checking presence of a threshold effect. Application of unit root tests indicated that both wholesale and retail prices are I (1), and Johansen test verified cointegration of the series in the long-run. Results of the Sup-LM test confirmed threshold adjustment of product price towards the long-run equilibrium. Furthermore, results obtained from TVECM revealed that the coefficient of ECT is significant only in the first regime of retailing equation implying that retailers significantly respond to the decreasing deviations from the long-run equilibrium. While adjustment coefficient is not significant for wholesale equation in both regimes to imply that there is not significant inclination to react to deviations from the long-run equilibrium among the wholesalers despite the retailers.

Keywords:
Hansen and Seo Approach, Threshold Vector Error Correction Model, Asymmetric Price Transmission, Vertical Integration, Zanjan

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INTRODUCTION

Study of price transmission helps to understand causes of changes in prices, necessary to address root causes. In addition, may help forecast prices based on trends in related prices and diagnose poorly functioning markets, as well. The process of price transmission in the food sector has long been one of the most attracting fields in the agricultural economics literature for policy purposes (Palakas and White, 1993). Many observers have claimed that brokers are more likely to increase than to lower the prices of food items. As a result, cost increases are completely and rapidly passed on to consumers, whilst there is a slower and less complete transmission of cost savings. Balke and Fomby (1997) pointed out that the presence of fixed costs of adjustment may prevent economic agents from adjusting continuously. Threshold models of dynamic economic equilibria have therefore gained increasing significance in the analysis of price transmission asymmetries.

Abdulai (2002) argued that a major flaw of previous studies on asymmetric price transmission in the food marketing chain is that they fail to take into account the possibility of the presence of equilibrium relationship between any price series being examined. The Cointegration and its corresponding Error Correction Models developed by Enders and Granger (1998) consider the time series properties of the variables, but do not presume a linear symmetric adjustment to study the transmission of producer price changes. In other words, since these models are able to modify the weaknesses concerned with the foregoing models, hence they have frequently been used.

Asymmetric price transmission is important because it can point out to gaps in economic theory. In addition, its presence is often considered for policy purposes to be evidence of market failure. Although price asymmetry has been empirically verified by several studies, there is not yet a general theoretical explanation for this phenomenon. A very interesting model developed by Azzam (1999) brought some light to retail's higher responsiveness to farm price increases. Using a two-period model of spatially competitive retailers, Azzam (1999) showed that price asymmetry can result from concave spatial demands. He also found that price transmission was only partial, which means that both farm price increases and decreases are transmitted less than proportionally by retailers. The relationship between farm and retail prices provides insights into marketing efficiency and consumer and farmer welfare. Because of that, agricultural economists have focused on the farm to retail price transmission process.

Peltzman (2000) used three samples consisting of producer, consumer and supermarket prices for estimation of asymmetric price response in Chicago and concluded that rises in prices are faster than their falls. Abdulai (2002) used data drawn from 117 monthly observations of producer and retail prices for pork in Switzerland from January 1988 to September 1997 and estimated the threshold cointegration. He concluded that Asymmetric Error Correction Model yields dynamic path consistent with adjustments to eliminate deviations from the long-run equilibrium, whereas the symmetric model did not. Aguiar and Santana (2002) studied price transmission from farm to retail in Brazil and estimated two different elasticities of price transmission; one for price increases and another for price decreases. They found that price increases are more rapid and fully transmitted than price decreases.

Ben-Kaabia *et al.* (2005) utilized a Three-Regime Threshold Vector Error Correction Model (TVECM(3)) in order to study price adjustments in the Spanish poultry sector and concluded that price adjustments between the farm and the feed levels are quite consistent with the existence of intensive vertical coordination between these two steps of the Spanish poultry marketing chain. Also reactions of both prices to positive and negative shocks are symmetric and producer prices are more flexible which suggests that there is a cost-push transmission mechanism. Vavra and Goodwin (2005) analyzed price transmission along the food chain and found that the most important alternative explanations for any finding of asymmetry are the presence of adjustment and menu costs. The presence of government interventions was also identified in the literature as a possible cause of price asymmetry. In recent years, price transmission in agricultural products has been of great interest among the Iranian agricultural economists as well. The followings are some examples in this regard.

Hosseini and Ghahremanzadeh (2006) analyzed price transmission behavior of red meat market by employing the TVECM and using the seasonal data for the period of 1994-2002. Their results indicated that price transmission between farm and retail is asymmetric to say that increase in prices is transmitted rapidly than decrease. Hosseini and Dourandish (2006) analyzed price transmission behavior of Iranian pistachio in the world market and obtained the results indicating asymmetric price transmission from farm-gate to export market and vice versa. Moreover, decrease in prices is transmitted fully and rapidly from farm to exporting market compared to increase in prices. Hosseini and Nikoukar (2006) examined price transmission in the Iranian chicken market and investigated its effect on marketing margin. Their results showed that decrease in prices is not transmitted fully and asymmetric price transmission in this sector is confirmed. They suggested not utilizing guaranteed prices and importing tariffs as instruments towards full price transmission to producers. Moghaddasi (2009) studied price transmission of Iranian pistachio market and found that sensitivity of retail prices to farm prices changes are different in short-run and long-run periods. Falsafian *et al*. (2010) applied a Multivariate Threshold Vector Error Correction Model for monthly mutton price data. Their results confirmed presence of non-linear cointegration relationship between the retail and farm prices. In addition, retailers show more strong responses to both positive and negative shocks imposed to the farmers. Rasouli and Ghahremanzadeh (2013) analyzed vertical price transmission of Iranian egg market by applying a Two-Regime Threshold Vector Error Correction Model (TVECM (2)) and using the daily data. They concluded that retailers respond to both positive and negative deviations from the long-run equilibrium, while wholesalers are reluctant in this respect. Meanwhile, retailers' responses to positive shocks are significantly higher compared to negative deviations.

The main objective of this study was to analyze asymmetric price transmission mechanism and nonlinear adjustment between the producer and retail prices of milk in Zanjan Province of Iran. To this end, we utilize a Two-Regime Threshold Vector Error Correction Model (TVECM) that developed by Hansen and Seo (2002) for checking presence of a threshold effect.

MATERIALS AND METHODS

Cointegration has been of much attention among economists since it was introduced by Granger (1981), because it enables researcher to test for existence of and find stable long-run relationships between nonstationary variables. However, a common property of all linear Vector Error Correction Models (VECM) discussed so far, is that the horizontal transmission is independent from the size of the shocks to the system. Threshold Vector Error Correction Models, yet, are able to determine the relationship between prices in various regions, by paying attention to the magnitude of the shocks. When a Threshold Cointegration Model is estimated, it is of crucial interest to test whether this nonlinear model is superior to a linear cointegration model. Hansen and Seo (2002) proposed such a test which tests a linear cointegration model against a Two-Regime Threshold Cointegration Model. This test uses the Sup-LM statistic which is the maximum of the LM function when the two thresholds vary over the set of all possible threshold values.

Threshold cointegration was introduced by Balke and Fomby (1997) in order to combine non-linearity and cointegration. They proposed a two-step method for analyzing the price dynamics in the univariate model. Accordingly, we should test the null hypothesis of no cointegration against the alternative of linear cointegration at first step. If the hypothesis of no cointegration rejected, in the next step the null hypothesis of linearity against the threshold cointegration would be examined (test of linearity). Afterwards, Lo and Zivot (2001) proposed a similar two-step strategy but they focused on multivariate estimation and testing procedures, instead. They applied a Threshold Vector Error Correction Model (TVECM) with a known cointegration vector. They argued that the multivariate threshold cointegration procedures that utilize the full structure of the model have higher power compared to univariate ones. Hansen and Seo (2002) developed a maximum likelihood based estimation theory for the TVECM with the unknown cointegration vector. They also provided the statistics required to test for the existence of a threshold effect in the Two-Regime Error Correction Model. For depicting their model, Let P_t $(RP_t,WP_t)'$ be the natural logarithms of the milk prices at retailing (RP_t) and wholesaling (WP_t) levels, supposing that P_t is a vector of I(1) time series which is cointegrated with a cointegrating vector $\beta = (1, -\beta)$. Also, let $Z_{t-1}(\beta)=\beta`P_t$ denote the I (0) error correction term. Following the mentioned theory, a Linear Vector Error Correction Model (VECM) of order $k+1$ is written as:

$$\Delta P_t = A_1' X_{t-1}(\beta) + u_t \quad (1)$$

Where $X_{t-1}(\beta)=[1 z_{t-1}(\beta)\ \Delta P_{t-1} \Delta_{t-2} \ldots \Delta_{t-k}]'$, $z_{t-1}(\beta)$ is the Error Correction Term and ut is the error term that supposed to be identically and independently distributed with a covariance matrix of Σ. So a Two-Regime Threshold Vector Error Correction Model (TVECM (2)) which is an extension of model (1) can be shown as follows:

$$\Delta P_t = \begin{cases} A_1' X_{t-1}(\beta) + u_t & if \quad z_{t-1}(\beta) \prec \lambda \\ A_2' X_{t-1}(\beta) + u_t & if \quad z_{t-1}(\beta) \succ \lambda \end{cases} \quad (2)$$

Where is the threshold parameter. Following the Hansen and Seo (2002), we estimated threshold parameter and cointegration vector using the grid search procedure over the two-dimensional space (β, λ) that relies on the logarithmic determinant of the estimated residual covariance matrix of the TVECM (2). The optimal threshold parameters and cointegration vector can be estimated using the following optimization program:

$$(\hat{\beta}, \hat{\lambda}) = \arg\min \left(\log \left[\hat{\sum_m}(\beta, \lambda) \right] \right) \quad (3)$$

Subject to the limitation of that is

$$\pi_0 \le T^{-1} \sum_{t=1}^{T} 1(P_t' \beta \le \lambda) \le 1 - \pi_0 \quad (4)$$

Where $\pi_0 > 0$ is a trimming parameter. Hansen and Seo (2002) suggested a method for estimating TVECM that is based on Maximum Likelihood function and involves a joint search over the threshold parameter and cointegrating vector. They developed a Sup-LM test for examination of linear cointegration against the alternative of threshold cointegration in a Two-Regime Threshold Vector Error Correction Model based on Lagrange Multiple (LM) statistic. They defined the Eicker–White covariance matrix estimators that yield the standard expressions for the heteroskedasticity-robust LM-like statistic as the following:

$$LM(\beta,\lambda) = vec(\hat{A}_1(\beta,\lambda) - \hat{A}_2(\beta,\lambda))'(\hat{V}_1(\beta,\lambda) + \hat{V}_2(\beta,\lambda))^{-1} \times vec(\hat{A}_1(\beta,\lambda) - \hat{A}_2(\beta,\lambda)) \quad (5)$$

Where $\hat{A}_1(\beta, \lambda)$ and $\hat{A}_2(\beta, \lambda)$ are respectively the parameters estimated in the first and the second regimes of the equation 2. Meanwhile, $\hat{V}_1(\beta,\lambda)$ and $\hat{V}_2(\beta,\lambda)$ are the Eicker-White covariance matrix estimators for $(\hat{A}_1(\beta, \lambda))$ and $(\hat{A}_2(\beta, \lambda))$, respectively. Due to the presence of nuisance parameter, they employed the Sup-LM statistic as follows:

$$SupLM = SupLM(\tilde{\beta}, \lambda) \quad \lambda_L \le \lambda \le \lambda_U \quad (6)$$

Where $\tilde{\beta}$ is the null estimate of the cointegrating vector and the search region $[\lambda_L, \lambda_U]$ is set so that λ_L and λ_U are π_0 and $(1-\pi_0)$ percentiles of $z_{t-1}(\tilde{\beta})$, respectively. The P-values of the Sup-LM test has been calculated by Hansen and Seo (2002) by the use of parametric residual bootstrap procedure. Two convenient methods of bootstrapping are the Residual Bootstrapping and the Fixed Regressor Bootstrapping (Stigler, 2011). For testing, the parameter π_0 should not be very close to zero, because such a case declines the power of test. Meanwhile, setting π_0 between 5 and 15 percent are typically good choices.

Data Source

This study utilizes wholesale and retail prices to examine asymmetry in price transmission of milk market chain price in Zanjan province of Iran. The data used in this analysis are based on 96 monthly observations of producer and retail prices for milk from March 2003 to February 2011. This information was drawn from agricultural organization of the province. Figure 1 shows the behavior of wholesale and retail monthly prices used in this study. Prices are

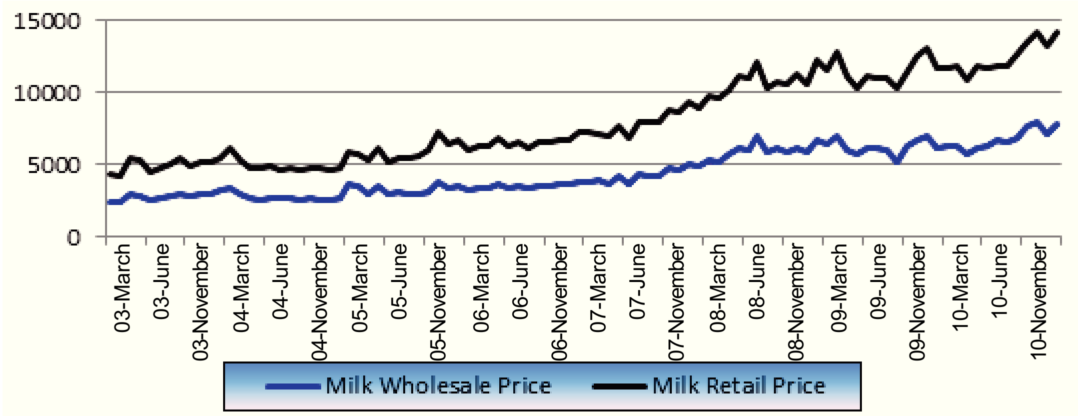

Figure 1: Wholesale and retail prices of milk in Zanjan province (Source: Research findings)

Table 1: Unit root and cointegration tests results.

Name of Test	Level		First Difference		Result
	Statistic	Critical Value (5%)	Statistic	Critical Value (5%)	
Wholesale Price					
ADF	-1.213	-2.894	-14.001	-2.895	I(1)
PP	-0.832	-2.894	-15.301	-2.895	I(1)
DF-GLS	-3.126	-3.046	-7.886	-2.137	I(1)
Retail Price					
ADF	-1.041	-2.894	-13.495	-2.895	I(1)
PP	-0.621	-2.894	-14.304	-2.895	I(1)
DF-GLS	-2.930	-3.046	-7.370	-2.137	I (1)

in Iranian currency (IRR)[1] per kilogram of product. As can be observed, the wholesale and retail prices show a similar pattern during the period although there is more volatility in recent years compared to early years. Furthermore, it is important to notice that the retail price tends to react slightly later than the wholesale price.

RESULTS AND DISCUSSION

Unit Root and Cointegration Tests

For testing whether the price series concerned are stationary, the Augmented Dickey-Fuller (ADF), DFGLS and Phillips-Perron (PP) unit-root tests were employed. In addition, the AIC was used to determine the appropriate lag-length truncation, which was found to be one in both cases. The related results are presented in the Table 1. As table 1 show all ADF, PP and DF-FGLS tests confirm that the price series are integrated in order one I (1).

In order to testing presence the cointegration relationship between wholesale and retail milk prices, the Johansen (1995)'s cointegration test was carried out. Table 2 shows results of the Trace and the Maximum Eigenvalue tests proposed by Johansen (1995). As it can be inferred from the table 2, both the trace and the maximum eigenvalue test strongly reject the null hypothesis of r=0 and accept the hypothesis r=1, thus the cointegration rank is one. Thus, there is one long-run relationship between wholesale and retail milk prices.

Table 2: Results of λ_{trace} and λ_{max} values of cointegration test.

Null Hypothesis	λ_{trace}	λ_{max}
r =0	19.33	16.57
r =1	0.556	0.556
Significance level	p <0.05	p <0.01

[1] *IRR = 0.0000335334 USD*

Threshold Vector Error Correction Model

In this study, we employed the Sup-LM test developed by Hansen and Seo (2002) to test the null hypothesis of linear cointegration against the Two-Regime Threshold Cointegration alternative by calculating the P-values by both the Fixed Regressor Bootstrap and Residual Bootstrap methods. We started the grid search with 100 grid points, and then re-estimated the model using 300 grid points for the threshold variables. The total number of the threshold candidates is one after excluding the bottom 5 percent of the ordered threshold variables, and after taking into account the possible same values of the threshold variables. By selecting 300 grid points, approximately every possible threshold candidate is evaluated if the threshold variables are uniformly distributed in the 90 percent middle range of the selection. The search range of β is defined as the linear consistent estimate of β, estimated from the linear cointegration model pluses and minuses 6 times of the estimated standard errors of β. After forming the grid points of threshold variables and the cointegrating variables, a two-dimensional grid search was conducted to find the values that maximize the likelihood function. Result of the Sup-LM Test proposed by Hansen and Seo is present in Table 3. This Table implies that the mechanism of the price transmission is of the threshold type. Therefore, we can utilize the Threshold Vector Error Correction model.

Table 4 represents the estimated coefficients of the Threshold Vector Error Correction Model. Table 4 shows the linear VECM that was estimated using the Error Correction Term generated by the Johansen method. The number of included lags was determined by AIC. It is important to note that the estimated coefficient of the Error Correction Terms (ECT) is statistically significant at the 10% level, only on the wholesale price equation. This indicates that the price adjustment to the long-run equilibrium take place only from the side of wholesale.

Table 5 summarizes the results of the Threshold Vector Error Correction Model that implies this model is more appropriate for analysis of the present data. Following Hansen and Seo (2002) the maximum likelihood was used for estimation. According to the table 5, the estimated cointegration relationship is $ECT_t=Ln(RP_t)-0.96Ln(WP_t)$ that is very close to a unit coefficient. The β estimate is approximately equal to one. The estimated threshold is λ=0.56. Hence, the first regime occurs when $Ln(RP_t)-0.96Ln(WP_t)\leq 0.56$. In this case, about 89 percent of observations fall into first regime, which Hansen and Seo call it "Typical" regime, because more than half the observations belong to this regime.

The second regime is when   which is known as the "Extreme" regime by Hansen and Seo and includes only 11 percent of the observations. It is necessary to note that the associated Wald test statistics rejected both the null hypothesis of equality of the dynamic coefficients and the null hypothesis for equality of ECM coefficients

Table 3: Result of the Sup-LM Test .

Sup-LM Statistic	**13.58**	
p-Value	0.084	Fixed Regressor Bootstrap
p-Value	0.104	Residual Bootstrap

Table 4: Result of Linear VECM Estimated by Johansen approach

Wholesale Price Equation			**Retail Price Equation**		
Variable	Coefficient	Standard Error	Variable	Coefficient	Standard Error
ECT	0.138	0.173	ECT	-0.313	0.182
$\Delta LnRP_{t-1}$	-0.046	0.191	$\Delta LnRP_{t-1}$	-0.151	0.177
$\Delta LnRP_{t-2}$	-0.363	0.163	$\Delta LnRP_{t-2}$	-0.183	0.188
$\Delta LnWP_{t-1}$	0.046	0.161	$\Delta LnWP_{t-1}$	0.074	0.153
$\Delta LnWP_{t-2}$	-0.226	0.177	$\Delta LnWP_{t-2}$	-0.154	0.157
Constant	-0.057	0.095	Constant	0.187	0.097
Cointegrating Vector = (0.042, 0.955)					

Table 4: Result of Linear VECM Estimated by Johansen approach.

Ln(RP)			Ln(WP)		
Variable	First regime	Second Regime	Variable	First regime	Second Regime
ECT	-0.416	0.996	ECT	-0.038	0.552
Significance level	P <0.01	P <0.1		P <0.1	P <0.1
Standard Error*	0.199	0.683	Standard Error	0.191	0.596
$\Delta LnRP_{t-1}$	-0.059	-0.705	$\Delta LnRP_{t-1}$	0.196	-1.164
Significance level	P <0.1	P <0.05		P <0.01	P <0.05
Standard Error	0.218	0.243	Standard Error	0.185	0.221
$\Delta LnRP_{t-2}$	-0.252	0.291	$\Delta LnRP_{t-2}$	-0.543**	0.213
Significance level	P <0.1	P <0.1		P <0.05	P <0.1
Standard Error	0.168	0.418	Standard Error	0.183	0.267
$\Delta LnWP_{t-1}$	0.224	-0.790	$\Delta LnWP_{t-1}$	0.269	-1.093
		P <0.01			P <0.05
Significance level	0.146	0.210	Standard Error	0.142	0.227
Standard Error	-0.292	0.886	$\Delta LnWP_{t-2}$	-0.345	0.332
$\Delta LnWP_{t-2}$	P <0.1	P <0.05		P <0.01	P <0.1
Standard Error	0.169	0.271	Standard Error	0.152	0.227
Constant	0.206	-0.574	Constant	0.032	-1.438
Significance level	P <0.05	P <0.1		P <0.1	P <0.01
Standard Error	0.092	0.423	Standard Error	0.087	0.341
Threshold Parameter: 0.56			Cointegration Vector: 0.96		
Percentage of observations in first regime: 89%			Percentage of observations in second regime: 11%		
Negative Log-Likelihood: -509.9871			AIC: -461.9871		
Wald Test for Equality of Dynamic Coefficients: 70.848 (P-value= 3.331668e-12)			Wald Test for Equality of ECM Coefficients: 17.295 (P-value= 0.0002)		

* denotes Eicker-White standard errors.

across the two regimes at 1% significance level. Thus the short-run dynamic effects of the retail and farm prices show significant differences between typical and extreme regimes. The milk retail price adjustment parameter is statistically significant at 1% level in typical but not significant in extreme regime, unlikely the wholesale price has not statistically significant error correction effects. This indicates that in the typical regime, containing the low marketing margin, adjustment toward long-run equilibrium takes place only from the side of the milk retailing price. In contrast, in the extreme regime that contains the bigger marketing margin, there is no adjustment to the long-run equilibrium. This implies that milk retailing price responds to any negative shocks in the long-run. However, the retail price presents two different adjustments. Consequently, within any month the retail price and the wholesale price would be respectively adjusted about 42 and 4 percent in response to a negative shock, generated in the previous period. On the contrary, in the case of positive shocks neither retailers nor wholesalers have enough tendencies to move towards the long-run equilibrium.

CONCLUSION

The objective of this study was to examine the mechanism of asymmetric price transmission and to discuss nonlinear adjustments between the wholesale and retail prices of milk in Zanjan province of Iran. Analysis of the data showed that milk wholesale and retail prices are perfectly integrated in the long-run, indicating that any change in each price is fully transmitted to another. Moreover, findings pointed out that there are nonlinearities in the studied price adjustment process. Furthermore, employing the Sup-LM test indicated that asymmetric price transmission behavior can be described by a Two-Regime Threshold Vector Error Correction Model (TVECM (2)). Application of the Two-Regime Threshold Vector Error Correction Model (TVECM) demonstrated that the coefficient of Error Correction Term (ECT) is significant only in the first regime of retailing equation. This implies that retailers respond significantly to the negative deviations from the long-run equilibrium. While coefficient of error correction term is not significant for wholesale equation in both regimes that indicates wholesalers have not enough inclination to respond to deviations from the long-run equilibrium. Therefore, it is recommended to policymakers to focus on the producer and wholesale prices rather than retail prices for controlling the fluctuations and volatilities in price of milk in Zanjan province.

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