WHOLESALE SPREADS AND THE DYNAMICS OF RETAIL PRICE VOLATILITY

BY

Raghbendra Jha
Hari K. Nagarajan

December 1998

Please address all correspondence to:

Hari K. Nagarajan
Assistant Professor
Indian Institute of Management
Bannerghatta Road
Bangalore - 560 076
India

Fax: (080) 6644050

Copies of the Working Papers may be obtained from the FPM & Research Office

Wholesale Spreads and the Dynamics of Retail Price Volatility[1]

Raghbendra Jha[a2] and Hari K. Nagarajan[b]

a. Indira Gandhi Institute of Development Research, Mumbai, India
b. Indian Institute of Management, Bangalore, India

Abstract

This paper proposes a general model of asymmetric price transmission at the retail level to examine the volatility of retail spreads in vertical markets, with endogenous overshooting of the wholesale spreads. The model is tested with Indian data and detects significant levels of asymmetry in price transmission. In addition it is found that endogenising the instability at the wholesale level is significant in explaining volatilities of retail spreads.

JEL Classification: C32, D43, Q13, Q18

Keywords: Volatility of retail spreads, Vertical markets, Partial adjustment models.

[1] This paper has benefited from the comments given by Professors Sugata Marjit and Ravi Anshuman Excellent research assistance from Sunila George is also acknowledged.
[2] Corresponding author. Fax: 91-22-8402752; E-mail: rjha@igidr.ac.in

I. Introduction

Multiple levels of traders, each, occupying a distinct position in the market hierarchy and performing a specific role characterize vertical markets. Such markets usually exist for commodities such as rice, wheat, meat products etc. that require, multiple stages of processing before reaching the end user. Frictions in information flows across the various levels of hierarchy exist in such markets. These frictions arise out of information asymmetries that exist at various levels of the market. Such frictions usually cause asymmetric transmission of shocks across the market. For example, the impact of an increase in the wholesale selling price at the retail level may not be the same as a corresponding decrease in the wholesale selling price. Such responses of prices, at a lower end of the market hierarchy are termed as asymmetric price response. It is defined as signifying the reaction of, for example. the retail prices, to changes in, for example. the wholesale and farm prices, depending on whether, these changes were positive or negative.

One of the primary concerns of the policy makers in economies that have vertical markets is controlling (or managing) the movements of the retail prices of the various commodities. These policy makers undertake various measures of price control. Retail prices usually adjust due to shifts in demand of various magnitudes. There is also a possible seasonal component to these movements. However one of the reasons for retail price movements is the retailer's own profit, and, information-seeking behavior. This is always the hidden component of retail price movements. A retailer's dynamic information-seeking behavior leads to the periodic and even continuous revision of the spreads at this level of the market. In vertical markets, this adjustment is not only affected by the retailer's expectations about various shocks at the demand and supply side but also exogenously impacted by various types of innovations[1] at the wholesale level. The impacts of events at the higher levels of the market hierarchy are transmitted in an asymmetric manner to the retail level.

In this paper we seek to investigate the asymmetric transmission of information from the wholesale and farm level to the retail level. One of the sources of instability to this process of transmission is the occurrence of events at the wholesale level. These events will cause the wholesale spreads to overshoot their true values to the extent that they were not perfectly anticipated. We posit that asymmetric information is endemic to vertical markets. In such circumstances, the overshooting of wholesale spreads will have a destabilizing effect on the movements of the retail spreads. We also show that endogenising the instability at the wholesale level in the process of measuring the asymmetric price transmission at the retail level is significant.

This paper is laid out in the following manner. Section II explains the model and the data that is used for estimation. In section III, we state the results of this estimation procedure and, section IV concludes.

II. Model and the Data

We propose a general model of price transmission in vertical markets. Here, we posit that, changes in retail spreads are, not only a function of the direction and magnitude of wholesale spread and farm prices, but also, is affected by the magnitude of overshooting of the wholesale spread.

The literature on asymmetric price transmission (non-reversibility) in vertical markets is extensive. Houck (1977) and earlier Wolffram (1971) have suggested an approach based on segmenting the explanatory variables involved, into positive and negative changes. These are linear models that help us understand whether for example, a positive or negative net relation exists between changes in the retail prices, retail spreads and, changes in the wholesale spreads and farm prices. Gardner (1975) and Heien (1980) offer equilibrium models for explaining differential impacts of changes in supply and demand on wholesale and retail prices that cause asymmetric price transmission of information from wholesale to the retail level. Wohlgenant (1985) offers an explanation based on the inventory control behavior using the rational expectation framework to examine the relationship between retail and wholesale prices. This is perhaps the first model that explains the role of inventories in the relationship between wholesale and retail spreads. Finally, Taubadel (1998) has proposed a model that is consistent with cointegration between prices at various levels in the market hierarchy.

While all the preceding models offer interesting insights into the price transmission process in vertical markets, there still is an important lacuna. For instance, none of these papers examine the role of profit seeking by the wholesalers in the process of price transmission. Changes in retail spreads are not only a function of the direction and the magnitude of changes in wholesale spread, and the farm price, but also, a function of the degree of stability of the changes in the wholesale spreads. If the changes in the wholesale spread are stable, i.e., if there is no overshooting then, it implies no order imbalance or information asymmetry at the wholesale level. This issue is especially important in the light of causal relationships that exist between wholesale spreads and retail spreads. In vertical markets, the causality runs in the direction of the lower levels of the hierarchy. That is, the whole sale spreads in these markets will Granger cause changes in the retail spreads and the retail prices. Another problem with these papers is that, the various markets in a given economy are treated as distinct entities. It is possible that both wholesale and retail markets across space could be informationally linked. This will affect price transmission within any vertical market.

We therefore propose a general method of estimating price transmission in vertical markets by endogenising the tendency of the wholesale spreads to overshoot. This is done by introducing a partial adjustment component (along the lines of Marsh (1994)) into the model for estimating the process of price transmission. The notion of partial adjustment has several appealing features. First, it is consistent with the idea of overshooting since, the change in spread is considered a function of excess spreads in the previous period. Second, the role of expectations is made explicit in explaining the changes in the spread. Expectations are formed by taking into account the various types of information asymmetries in the market place and the spread in the previous period. Hence, the model also has properties of adaptive expectations.

Wholesalers are constantly engaged in dynamic information acquisition. In a perfect foresight world, this will not have any impact on the process of price transmission in vertical markets. However, as noted earlier, information asymmetry is endemic to vertical markets. In this context dynamic information acquisition will induce instabilities into the system. This process is therefore endogenised in the model of price transmission as in Chavas and Holt (1993).

Let R_{it} be the retail spread in market i at time t, and, W_{it} and F_{it}, the corresponding wholesale spread and farm prices. The target spread at the wholesale level, which is unobservable, is SP^*_{it}. We segment the variables W_{it} and F_{it}, in the manner prescribed in Houck (1977) into positive and negative changes. Hence;

$W^{'}_{it} = W_{it} - W_{it-1}$ if $W_{it} > W_{it-1}$, and = 0 otherwise ...(a)

$W^{"}_{it} = W_{it} - W_{it-1}$ if $W_{it} < W_{it-1}$ and = 0 otherwise ...(b)

$F^{'}_{it} = F_{it} - F_{it-1}$ if $F_{it} > F_{it-1}$ and = 0 otherwise ...(c)

$F^{"}_{it} = F_{it} - F_{it-1}$ if $F_{it} < F_{it-1}$ and = 0 otherwise ...(d)

Using this, we can write the model of price transmission in each market as:

$$\Delta R_{it} = \alpha_{i0} - \alpha_{i1}\Delta W^{'}_{it} - \alpha_{i2}\Delta W^{"}_{it} + \alpha_{i3}\Delta F^{'}_{it} + \alpha_{i4}\Delta F^{"}_{it} + \theta_i(SP^*_{it} - SP_{it-1}) + \varepsilon_{it} \qquad \ldots(1)$$

Where θ_i measures the rate of overshooting of the wholesale spread in market i. The term (SP^*_{it} - SP_{it-1}), captures the deviation of the wholesale spread from its target value. The target spread SP^*_{it} is a function of inventory level (measuring the order imbalance in the system), and, the lagged retail selling price. The target or the expected value of the retail bid ask spread might be unobservable[2]. We can therefore write the target spread as follows

$$SP_{it}^{*} = \beta_i (st_{it-1}, rtl_{it-1}) \qquad \ldots(2)$$

Where, st_{it-1} is the wholesale inventory (stocks) at time t-1, and, rtl_{it-1} is the retail selling price at time t-1. Substituting equation (1) in equation (2) and expanding, we have

$$\Delta R_{it} = \alpha_{i0} - \alpha_{i1}\Delta W_{it}^{'} + \alpha_{i2}\Delta W_{it}^{"} + \alpha_{i3}\Delta F_{it}^{'} + \alpha_{i4}\Delta F_{it}^{"}$$

$$+\theta_i \beta_{i1} st_{it-1} + \theta_i \beta_{i2} rtl_{it-1} - \theta_i SP_{it-1} + \varepsilon_{it} \qquad \ldots(3)$$

We also note that,

$$R_{it} = R_{i0} + \sum_{t=1}^{n} \Delta R_{it} \qquad \ldots(4)$$

Where, R_{i0} is the initial value of the retail spread in market i at any point in the time interval. We can write (8) as follows

$$R_{it} - R_{i0} = \sum_{t=1}^{n} \Delta R_{it} \qquad \ldots(5)$$

Which is the sum of the period to period changes in retail spreads. Recognizing this for the other segmented variables in (a) to (c), we can rewrite equation (5) as follows

$$R_{it} - \Delta R_{i0} = \alpha_{i0} + \alpha_{i1}\Sigma\Delta W_{it}^{'} + \alpha_{i2}\Sigma\Delta W_{it}^{"} + \alpha_{i3}\Sigma\Delta F_{it}^{'} + \alpha_{i4}\Sigma\Delta F_{it}^{"}$$

$$+\theta_i \beta_{i1} st_{it-1} + \theta_i \beta_{i2} rtl_{it-1} - \theta_i SP_{it-1} + \varepsilon_{it} \qquad \ldots(6)$$

Equation (6) is now estimated as a nonlinear system of equations for i = 1…n markets in any given economy.

Following Randolph(1991), the magnitude of the impact of the rate of mean reversion of wholesale spread, on the retail markets is measured by

$$W_{imp} = \frac{\ln 2}{\theta_i} \quad \ldots (7)$$

Where W_{imp} is the "impact factor" of the half-life of the innovation affecting the wholesale markets. Hence, wholesale markets that are noisy can cause short-term impacts on the retail markets. It is also possible for wholesale markets where mean reversion is absent, to have an impact on the movement of the retail spreads. This reflects the direction of causality in the vertical markets.

We estimate equation (6) using Indian data on rice for 14 centers that are spatially separated. The Indian rice markets fall into the category of vertical markets where the middlemen are the wholesalers who purchase grain from the farmers and sell to the retailers. We use weekly data for the period 1990-1994, on wholesale spreads, wholesale selling prices, farm prices, retail spreads and, wholesale inventories, to estimate our model. The Ministry of Civil Supplies Government of India provided this data. The next section describes the results of this estimation procedure.

III. Results

The results of the estimation of the generalized model are shown in table (1). We detect significant degrees of asymmetric price transmission. The coefficients α_1, α_2, α_3 and α_4 are negative and unequal. This suggests that a negative net relationship between the movements of the retail spreads wholesale selling price, and, farm price. A test for asymmetric price transmission is to test the hypothesis whether $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4$. This is rejected at the 5% level.

What role does overshooting of wholesale spreads play on the lower levels of the market hierarchy? The relationship between the half-life of innovations at the wholesale level and changes in the retail spread is positive. That is, overshooting tends to widen the retail spreads for the most part. The impact factor, of the wholesale spread is consistently positive. In addition to this, we observe that whenever the impact factor is large, the volatility of the retail spreads is also higher. This is shown in figure (1). We find that overshooting of spreads at the wholesale level create incentives for retailers to hoard. This is evident from the sign on the variable st. If this is positive then, an increase in the order imbalances will widen spreads. This result is applicable to 6 centers viz., Ahmedabad, Bangalore, Cuttack, Kanpur, Madurai and Vijayawada. It is interesting to note that 4 of these centers viz., Ahmedabad, Bangalore, Cuttack and Kanpur are major industrial towns with a large consuming population.

One of the innovations in this paper is the introduction of the partial adjustment term in the process of price adjustment at the retail level. It is imperative that we check whether this generalization is valid. To this end we compute the following non-parametric statistic:

$$\lambda = 2(l(\rho^u) - l(\rho^r))$$

Where $l(\rho^u)$ represents the value of the log of the likelihood function with unrestricted values of the vector of parameters ρ and $l(\rho^r)$ represents the log of the likelihood function with r restrictions. (In our case the restrictions are that all parameters associated with the partial adjustment term are zero). The statistic λ is distributed as a χ^2 with r degrees of freedom (see Davidson and MacKinnon (1993)) under the null hypothesis that the restrictions hold. In the present case the value of λ (with 42 degrees of freedom) is 222.914 which is much higher than the critical value of chi-squared with 42 degrees of freedom at even the one per cent level. These restrictions are, hence, strongly rejected, indicating that the more general model of price adjustment presented in this paper is more suitable. Results for the restricted model are reported in Table 2. Even though we continue to detect asymmetry in price transmission, we fail to reject the hypothesis of equality of the coefficients α_1,α_2, α_3 and α_4 at the 5% level of significance for all centers. For some centers we can reject this at 10%. This reinforces our claim that endogenising the instability at the wholesale level into the model of price adjustment at the retail level significantly influences asymmetric price transmission.

Notes

1. Innovation is defined as an information shock that causes information asymmetries. This will have a bearing on the future prices, and the traded volumes. We might expect the current spreads to adjust in order to reflect these informational asymmetries. In the world of rational expectations, the change in the current spread will equal the expected change and more importantly, the time taken for any spread adjustment is nearly zero. We however assume that the wholesalers have imperfect information regarding future prices and volumes causing spread adjustments to be sluggish. Government announcements regarding procurement/support prices, sudden strikes, information regarding monsoons, etc., constitute innovation, since these will affect the true price perceptions of the wholesalers.

2. The stipulation that the target spread is unobservable is common in the market microstructure literature in finance. See George, Kaul and Nimalendran (1993).

Table 1

Nonlinear model of price transmission with endogenous overshooting[3]

Centre	Independent Variables							
	constant	$\Sigma\Delta X'$	$\Sigma\Delta X''$	$\Sigma\Delta Z'$	$\Sigma\Delta Z''$	theta	rtl	st
Ahmedabad	1.040 (2.3972)	-.041 (-2.9577)	-.047 (-2.4533)	-.246 (-2.3431)	-.517 (-1.9837)	.059 (3.1421)	.050 (2.50)	1.970 (7.2388)
Amritsar	1.987 (5.4537)	-.1708 (-9.2331)	-.726 (-6.003)	-.789 (-8.4628)	-1.447 (-10.423)	.084 (9.5705)	8.220 (8.0604)	-.019 (-5.0311)
Bhubhaneshwar	1.040 (2.37)	-.054 (-3.58)	-.0003 (-1.985)	-.191 (-2.01)	-.313 (-1.85)	.072 (4.97)	3.961 (3.22)	-.923 (-22.948)
Bangalore	.455 (2.36)	-.274 (-2.98)	-.011 (-1.31)	-.028 (-1.95)	-.886 (-5.44)	.051 (4.16)	4.206 (4.22)	.068 (3.58)
Chandigargh	1.174 (1.63)	-.221 (-1.78)	-.081 (-2.91)	-.573 (-3.41)	-.764 (-2.81)	.128 (8.74)	1.651 (1.423)	-.0005 (-4.9962)
Cuttack	.870 (2.93)	-.533 (-6.92)	-.0007 (-7.93)	-.108 (-5.48)	-1.417 (-7.41)	.178 (9.82)	3.382 (3.91)	1.151 (6.22)
Karnal	1.262 (2.32)	-.099 (-5.48)	-.991 (-1.29)	-.111 (-8.61)	-1.198 (-5.62)	.130 (7.21)	.538 (2.499)	-.325 (-15.478)
Kanpur	.581 (1.91)	-.026 (-2.99)	-.081 (-4.21)	-.0002 (-2.43)	-.603 (-3.24)	.048 (2.57)	4.714 (6.32)	.082 (5.83)
Lucknow	.612 (1.50)	-.160 (-7.32)	-.00007 (-2.49)	-.051 (-2.63)	-.396 (-1.44)	.0897 (6.85)	2.157 (2.48)	-.013 (-5.43)
Ludhiana	1.583 (4.22)	-.052 (-3.62)	-.012 (-1.97)	-.050 (-2.71)	-.400 (-2.53)	.064 (5.65)	1.747 (2.12)	-.467 (-7.09)
Madurai	1.780 (2.14)	-.064 (-5.22)	-.00016 (-5.38)	-1.045 (-5.10)	-.763 (-3.36)	.060 (5.33)	1.745 (2.67)	.236 (38.67)
Patna	.573 (1.69)	-.033 (-2.44)	-.012 (-1.97)	-.042 (-2.13)	-.595 (-2.44)	.052 (6.23)	10.476 (11.04)	-.044 (-2.41)
Shimla	1.144 (1.97)	-.049 (-3.45)	-.012 (-1.87)	-.254 (-1.82)	-1.375 (-6.35)	.075 (5.42)	3.000 (3.44)	-.015 (-1.44)
Vijayawada	.474 (1.86)	-.066 (-5.28)	-.021 (-3.36)	-.029 (-1.45)	-.436 (-1.98)	.088 (4.73)	2.632 (2.95)	.189 (9.59)

[3] Log of likelihood function: -555.3591, figures in parentheses indicate t-values.

Table 2

Nonlinear model with the restriction that the partial adjustment part is inoperative[1]

Centre	Independent Variables				
	constant	$\Sigma\Delta X'$	$\Sigma\Delta X''$	$\Sigma\Delta Z'$	$\Sigma\Delta Z''$
Ahmedabad	-.087 (-1.8321)	-1.0125 (-4.3085)	-1.0728 (-4.2578)	-1.3935 (-2.1376)	-1.3679 (-3.3053)
Amritsar	-.0247 (-.9041)	-.4151 (-3.3376)	-.4092 (-1.6277)	-.2113 (-.8179)	-.0315 (-.1216)
Bhubhaneshwar	.0130 (.4451)	-.1422 (-1.3633)	-.1702 (-2.8161)	-.5497 (-1.277)	-.5246 (-1.0831)
Bangalore	.0308 (1.0422)	-.5311 (-1.8509)	-.4759 (-2.281)	-.0171 (-.0459)	-.0025 (-.00048)
Chandigargh	-.0798 (-2.5016)	-1.1091 (-5.1608)	-1.1539 (-4.7457)	-.9627 (-3.1626)	-.9482 (-3.4622)
Cuttack	-.0752 (-1.7811)	-.7911 (-2.0698)	-.7578 (-2.2903)	-.8171 (-2.3120)	-.9533 (-2.2676)
Karnal	-.0306 (-.8397)	-.1584 (-.5742)	-1.4580 (-.1615)	-1.893 (-4.9899)	-.0331 (-.0826)
Kanpur	.0022 (.0531)	-.7588 (-4.4952)	-.7963 (-6.7449)	-.9243 (-3.9409)	-.8954 (-4.0711)
Lucknow	-.0523 (-1.6260)	-1.0533 (-7.2407)	-1.1041 (-.1184)	-.8803 (-3.6762)	-.8501 (-3.090)
Ludhiana	-.0026 (.0982)	-.5936 (-2.7868)	-.5674 (-3.8453)	-.6036 (-3.0134)	-.5990 (-2.3025)
Madurai	-.1021 (-2.5822)	-1.3975 (-7.6266)	-1.4304 (-6.1820)	-1.1806 (-3.9073)	-1.1693 (-4.1551)
Patna	-.0363 (-1.1451)	-1.1005 (-6.3516)	-1.0065 (-6.4999)	-1.4474 (-4.9546)	-1.4586 (-4.4279)
Shimla	-.0412 (-1.1467)	-1.0634 (-7.0636)	-.9850 (-7.4888)	-1.1243 (-6.4496)	-1.2129 (-5.8385)
Vijayawada	-.0202 (-.6779)	-.6253 (-3.1240)	-.6466 (-4.062)	-1.1947 (-3.697)	-1.2304 (-3.3729)

[1] Log of likelihood function: -443.9024. figures in parentheses indicate t-values.

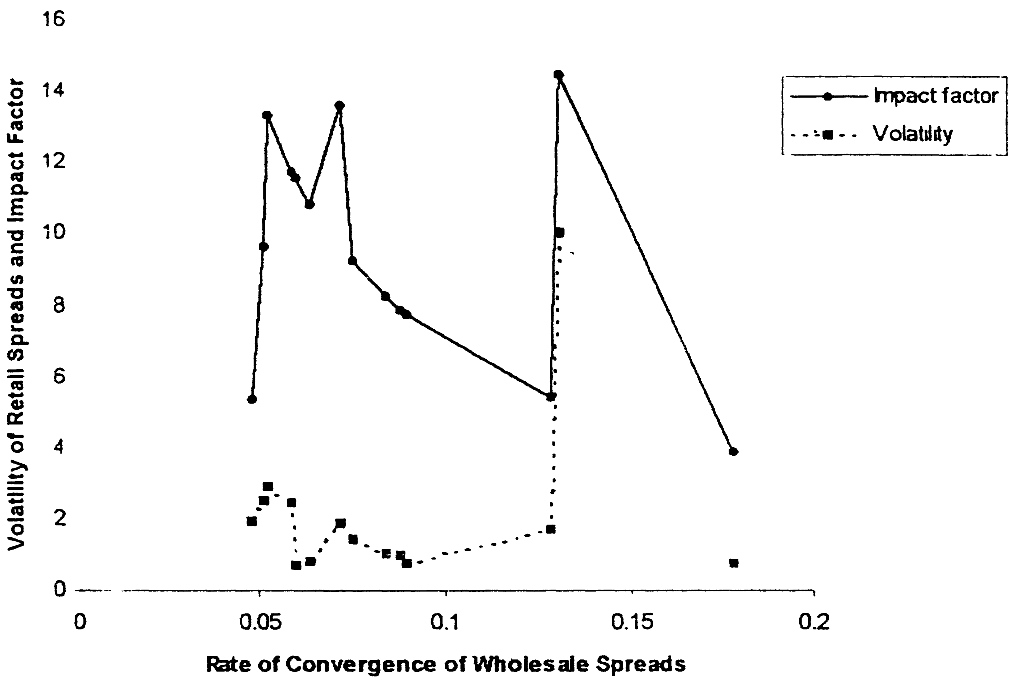

Figure (1)
Impact of the Innovations at the Wholesale levels on the Volatility at the Retail Spreads

References

1. Chavas, Jean-Paul, Holt, Holt, Matthew T. "Market Instability and Nonlinear Dynamics." *American Journal of Agricultural Economics* 75(February 1993): 113-120.
2. Davidson, R. and J. Mackinnon. Estimation and Inference in Econometrics, New York, Oxford University Press, (1993).
3. Gardner, B.L. "The Farm-retail Price Spread in a Competitive Food Industry." *American Journal of Agricultural Economics* 57(August 1975): 399–409.
4. George, T.H., G. Kaul, and M. Nimalendran "Estimation of the Bid-Ask Spread and its components: A new approach", *Review of Finance Studies* 4(1991): 623-656.
5. Heien, D.M. "Markup Pricing in a Dynamic Model of the Food Industry." *American Journal of Agricultural Economics* 62(February 1980): 10-18.
6. Houck, P.J. "An Approach to Specifying and Estimating Nonreversible Functions." *American Journal of Agricultural Economics* 59(August 1977): 570-572.
7. Marsh, John M. "Estimating Intertemporal Supply Response in the Fed Beef Market." *American Journal of Agricultural Economics* 76(August 1994): 444–453.
8. Randolph W.L. "Use of the mean reversion model in predicting stock market volatility", *Journal of Portfolio Management,* 17(1991): 22-26
9. Taubadel, Stephan von Cramon. "Estimating Asymmetric Price Transmission with the Error Correction Representation: An Application to the German Pork Market." *European Review of Agricultural Economics* 25(1998): 1-18.
10. Wohlgenant, M.K. "Competitive Storage, Rational Expectations, and Short-run Food Price Determination." *American Journal of Agricultural Economics* 67(1985, November): 739-748.

11 Wolffram, R "Positivistic Measures of Aggregate Supply Elasticities. Some New Approaches - Some Critical Notes." *American Journal of Agricultural Economics* 53(May 1971) 356-359