# Vertical Price Leadership within a Channel: A Cointegration Study

W. Erno Kuiper and Matthew T.G. Meulenberg
Marketing and Consumer Behaviour Group
Department of Economics and Management
Wageningen Agricultural University
Hollandseweg 1
6706 KN Wageningen
The Netherlands
tel. +31 (0)317483901
fax: +31 (0)317484361
E-mail: erno.kuiper@alg.menm.wau.nl

## ABSTRACT

This paper is concerned with the question whether or not retailers allow suppliers to set their prices not only on the basis of the costs faced by the suppliers but also on the basis of consumer demand, i.e., whether or not suppliers are able to use foresight (i.e., behave as vertical price leaders in the sense of Stackelberg leadership) by having the economic power and managerial ability to take into account the reactions of the downstream retailers to changes in suppliers' wholesale prices. Using standard theory, long-run price relationships between the stages in the channel are derived. Next, these static price relationships are imposed on a dynamic model to be tested for cointegration and error-correction structure. An empirical application to two Dutch marketing channels for food products gives conceivable results.

KEYWORDS. Marketing channel, Price leadership, Time series, Cointegration, Vector error-correction model

## INTRODUCTION

Most consumer food products are sold through independent retailers who sell a wide variety of substitutes. These companies are often larger than many suppliers, in particular in agricultural food chains, and are gaining more and more influence on how and which goods are distributed and at what price (Choi, 1996). These observations suggest that suppliers are forced to set their prices largely on the basis of their costs and do not have the opportunity to set their prices also on the basis of consumer demand.

On the other hand, in the marketing literature most channel studies have traditionally approached the problem from the supplier's perspective. Typical applications have been that retailers are passive decision makers and that manufacturers can influence their retailers' decisions through various incentives, pricing schedules, and cooperation (Choi, 1996).

The objective of this paper is twofold. First, a model is developed to study strategic (i.e., long-run) pricing decisions within channels and to determine the profit maximising long-run relationships for the channel members in a single-supplier (on the wholesale level), single-retailer channel dealing with a single product. Second, the long-run price relationships are examined in a dynamic (i.e., short-run) context to consider the possible existence and nature of a long-run relationship between wholesale prices and retail prices. If a meaningful long-run price relationship is found, then it can be investigated whether or not wholesale prices and retail prices respond to changes in the magnitude by which these two prices are out of equilibrium. Based on the assumption that retail margins are mean-reverting, two situations appear to be of interest: 1. both retail and wholesale prices respond to the equilibrium error, and 2. only the retail prices respond to the equilibrium error. In situation 1 the suppliers have sufficient power vis á vis the retailers to use foresight (the expression 'foresight is adopted from Lee and Staelin, 1997), i.e., to behave as vertical price leaders in the sense of Stackelberg leadership by taking into account the reactions of the downstream retailers to changes in their wholesale prices. In contrast, in situation 2 the retailers do not allow suppliers to influence retail prices beyond fluctuations in supplier's cost (including, among others, the prices of the raw materials and a margin enabling the supplier to continue its activities) and leave them only with the freedom to set their prices on the basis of their costs. Two empirical food product cases illustrate the procedure: coffee products and potato products. It is hypothesized that coffee tends to situation 1 while potato products better fit into situation 2. The empirical results provide evidence for these hypotheses.

The paper is organised as follows. After the introduction, the formulation of the long-run model and its testable implications on the short-run price system are dealt with. Next, the empirical results are presented. The paper closes with a summary of the main conclusions.

## METHOD

We consider the case of a two-member channel and model channel members' long-run supply decision behaviour. A single upstream firm, called the supplier, produces an intermediate good at a constant unit cost (including the price of the raw materials), $c_s$, and sells it to a single downstream firm, called the retailer, at a wholesale price $p_s$. The retailer faces constant unit retailing cost, $c_r$, and resells the product to the consumer at a price $p_r$. It is assumed that the retailer does not throw away any of the intermediate good. Consequently, the quantity bought by the retailer, denoted by $q$, is equal to the final consumption.

Static consumer demand behaviour is specified by a log-linear demand equation (cf. Von Ungern-Sternberg, 1994):

$$\ln(q_t) = \delta \ln(p_{rt}) + x_t \qquad (\delta < -1) \qquad (t = 1,\ldots,T), \qquad (1)$$

where $\delta$ is the price elasticity of demand and $x_t$ captures the shift in the demand curve at time $t$.

Let us first consider the Stackelberg model in which the supplier is the vertical price leader, i.e., the retailer maximises its profit conditional on the wholesale price that it has to pay to the supplier and next, the supplier determines $q$, and hence, the wholesale price, by maximising its profit while taking the conditional profit-maximising behaviour of the retailer into account.

The conditional profit-maximisation problem of the retailer can be written as

$$\max_{q_t} (p_{rt} - c_{rt} - p_{st})\, q_t \tag{2}$$

subject to (1). The first order condition for this problem is

$$p_{rt} + (\partial p_{rt}/\partial q_t)\, q_t - c_{rt} - p_{st} = 0 \tag{3}$$

from which it follows that

$$p_{rt} = [\delta/(1 + \delta)][\,p_{st} + c_{rt}]. \tag{4}$$

The supplier maximises its individual profit while taking the conditional profit-maximising behaviour of the retailer into account (i.e., while using foresight) so that

$$\max_{q_t} (p_{st} - c_{st})\, q_t \tag{5}$$

is subjected to (4) and has the following first-order condition

$$p_{st} + (\partial p_{st}/\partial q_t)\, q_t - c_{st} = 0, \tag{6}$$

from which it follows that

$$p_{st} = -[(1 + \delta)/\delta^2]\, p_{rt} + c_{st}. \tag{7}$$

Notice that if the retailer does not take $p_{st}$ as given as was assumed in (3), then it can be derived that

$$p_{rt} = [\delta/(1 + \delta)][c_{rt} + c_{st}], \tag{8}$$

which is the price being chosen if the retailer and the supplier determine $q_t$ by maximising total channel profits as if they were an integrated industry.

We can solve (4) and (7) for $p_{rt}$ and $p_{st}$, giving

$$p_{rt} = [\delta/(1 + \delta)]^2[c_{rt} + c_{st}] \tag{9}$$

and

$$p_{st} = [1/(1+\delta)][\delta c_{st} - c_{rt}]. \tag{10}$$

Notice that because $\delta < -1$, comparing (8) with (9) shows that the retail price is lower in the case of the integrated industry and hence, $q_t$ will be larger and therefore, again because of the elastic consumer demand with respect to the retail price, the integrated industry makes more profit than the non-integrated industry. This is the well-known vertical externality due to 'double marginalisation'. See, for example, Tirole (1988: 174, 175).

In this study it is of interest to notice that if the prices are set according to (9) and (10), then the supplier has enough power vis-á-vis the retailer to use foresight in order to determine $p_{st}$. However, if the retailer dominates, then we may have a situation as modelled by (8) in which case the retailer maximises profit and forces the supplier to set its price only on the basis of $c_{st}$. For simplicity, let

$$p_{st} = c_{st} \tag{11}$$

in that situation. Thus, two models are considered: the model made up by (9) and (10), or similarly, (2) and (5), according to which the supplier is able to manipulate the retail price by $\partial p_{st}/\partial q_t$ in (6), and the model formed by (8) and (11) which says that the retailer dominates, i.e., $\partial p_{st}/\partial q_t = 0$ in (6). The testable implications of these models will now be discussed.

Many economic time series, like $p_{rt}$ and $p_{st}$, do not fluctuate around a constant in a seemingly random way, but their first differences, $\Delta p_{rt} = p_{rt} - p_{r,t-1}$ and $\Delta p_{st} = p_{st} - p_{s,t-1}$, do (Granger and Newbold, 1986). Consequently, the variables in levels, $p_{rt}$ and $p_{st}$, are supposed to be nonstationary, while they will be stationary in first differences. In time series analysis this is expressed by saying that $p_{rt}$ and $p_{st}$ are integrated of order one, denoted $p_{rt} \sim I(1)$ and $p_{st} \sim I(1)$, and $\Delta p_{rt}$ and $\Delta p_{st}$ are integrated of order zero, denoted $\Delta p_{rt} \sim I(0)$ and $\Delta p_{st} \sim I(0)$.

The nonstationarity is caused by a so-called 'stochastic trend' (Banerjee et al., 1993: 153), which can be interpreted as the driving force of the variable. If two variables are driven by the same stochastic trend, then a linear combination of the two will be stationary, which is expressed by saying that the two variables are 'cointegrated' (Engle and Granger, 1987).

At first sight, there appear to be three variables in the model by which a stochastic trend could enter the price system: $x_t$, $c_{rt}$ and $c_{st}$. However, according to (8) - (11) the prices depend only on the cost variables $c_{rt}$ and $c_{st}$, but not on $x_t$; $q_t$ fully captures $x_t$ in (1) after $p_{rt}$ is set by the pricing decisions of the channel members. Further, we may assume that $c_{rt}$ does not contain a stochastic trend of importance when compared with the stochastic trend generated by the prices of the raw materials being included in $c_{st}$. Consequently, we assume that $c_{st}$ introduces the stochastic trend in the price system.

Because $c_{rt}$ is assumed to be stationary while $p_{rt}$ and $p_{st}$ are nonstationary due to $c_{st}$, the long-run (i.e., cointegrating) relationship between $p_{rt}$ and $p_{st}$ is given by (4). If the supplier is not dominated by the retailer, i.e., (2) and (5) apply, then (7) shows that there is a linear combination of $p_{rt}$ and $p_{st}$ that captures the stochastic trend in $c_{st}$. In contrast, if the retailer dominates, i.e., (8) and (11) apply, then (11) shows that $p_{st}$ is the only one that captures the stochastic trend and is then substituted in (8) so that (8) reduces to (4), the cointegrating relation. To see why it is of interest to know which variables capture the stochastic trend, we have to introduce the concept of error-correction.

The long-run equilibrium between $p_{rt}$ and $p_{st}$ can only exist if at least one of the prices responds to the equibrium errors in such a way that the equilibrium error will never become nonstationary (i.e., will always be mean-reverting). This is called error-correction (Engle and Granger, 1987). If both $p_{rt}$ and $p_{st}$ capture the stochastic trend, then both prices will show error-correction. If just one of both prices, for example, $p_{st}$, captures the stochastic trend, then only the other one, i.e., $p_{rt}$, will display error-correcting behaviour (Granger and Lin, 1995, and Gonzalo and Granger, 1995). This brings us to a testable hypothesis that discriminates between the two channel models. Given that $p_{rt}$ is error-correcting, we can test whether or not $p_{st}$ responds to the equilibrium error. Under the null hypothesis $p_{st}$ does not respond which complies with the dominating-retailer (vertical integration) model. If the null hypothesis is rejected in favour of the alternative hypothesis according to which $p_{st}$ displays error-correcting behaviour, then we conclude that the supplier has some price-setting power vis-á-vis the retailer as described by the Stackelberg model, equations (1) - (7) and (9) and (10).

The hypothesis on error-correcting behaviour can only be tested if a meaningful long-run relationship between $p_{rt}$ and $p_{st}$ can be found. To perform the cointegration and error-correction tests, a dynamic model must be specified. For this purpose, let us consider the following bivariate vector autoregression (VAR):

$$X_t = \sum_{i=1}^{k} \Pi_i X_{t-i} + \mu + \Phi D_t + \varepsilon_t , \qquad (12)$$

where $X_t = [p_{rt}, p_{st}]'$ are the prices, $\mu = [\mu_r, \mu_s]'$ are the intercepts, $D_t$ are centred seasonal dummies which sum to zero over a full year, $\varepsilon_1,...,\varepsilon_T$ are $IIN_2(0,\Lambda)$ and the values of $X_{-k+1},...,X_0$ are fixed. The VAR in (11) can be reformulated into a vector error-correction (VECM) form:

$$\Delta X_t = \Pi X_{t-1} + \sum_{j=1}^{k-1} \Gamma_j \Delta X_{t-j} + \mu + \Phi D_t + \varepsilon_t , \qquad (13)$$

where

$$\Delta X_t = X_t - X_{t-1},\ \Pi = \sum_{i=1}^{k} \Pi_i - I \text{ and } \Gamma_i = -\sum_{j=i+1}^{k} \Pi_j .$$

Notice that there can never be a relationship between a variable with a stochastic trend and a variable without a stochastic trend. So if $\Delta X_t \sim I(0)$ and $X_t \sim I(1)$ (and hence, $X_{t-1} \sim I(1)$), then $\Pi$ will be a zero matrix except when a linear combination of the variables in $X_t$ is stationary, i.e., when $p_{rt}$ and $p_{st}$ are cointegrated (or when one of the prices is stationary so that we should also test for the absence of each individual price in the cointegrating relation to justify our assumption that both prices are $I(1)$). Because this linear combination is unique, the rank of $\Pi$ will be equal to one, i.e., rank($\Pi$) = 1. Hence, rank($\Pi$) = 0 if there is no cointegration and rank($\Pi$) = 2 if $X_t \sim I(0)$. The Johansen procedure (Johansen and Juselius, 1990, and Johansen, 1995) estimates (13); to test for cointegration, trace statistics are used to determine the rank of $\Pi$, and (other) likelihood ratio (LR) statistics are used to test for the absence of each individual price in the long-run equilibrium in order to check whether both price series are $I(1)$.

Clearly, the result of interest will be rank($\Pi$) = 1. In this case $\Pi$ can be decomposed into $\Pi = \alpha\beta'$, where $\alpha = [\alpha_r, \alpha_s]'$ is the adjustment matrix and $\beta = [\beta_r, \beta_s]'$ is the cointegration matrix, and (13) can be rewritten in full as:

$$\begin{bmatrix}\Delta p_{rt}\\ \Delta p_{st}\end{bmatrix} = \begin{bmatrix}\alpha_r\\ \alpha_s\end{bmatrix}\begin{bmatrix}\beta_r & \beta_s\end{bmatrix}\begin{bmatrix}p_{r,t-1}\\ p_{s,t-1}\end{bmatrix} + \sum_{i=1}^{k-1}\begin{bmatrix}\Gamma_{i,rr} & \Gamma_{i,rs}\\ \Gamma_{i,sr} & \Gamma_{i,ss}\end{bmatrix}\begin{bmatrix}\Delta p_{r,t-i}\\ \Delta p_{s,t-i}\end{bmatrix}$$

$$+\begin{bmatrix}\mu_r\\ \mu_s\end{bmatrix} + \begin{bmatrix}\phi_{r1} & \cdots & \phi_{r11}\\ \phi_{s1} & \cdots & \phi_{s11}\end{bmatrix}\begin{bmatrix}D_{1t}\\ \vdots\\ D_{f-1,t}\end{bmatrix} + \begin{bmatrix}\varepsilon_{rt}\\ \varepsilon_{st}\end{bmatrix},$$

(14)

where, for example, $f = 12$ in the case of monthly data. The adjustment matrix can be used to test for the absence of error-correcting behaviour. If $\alpha_s = 0$, then $\Delta p_{st}$ does not respond to the equilibrium error $\beta_r p_{r,t-1} + \beta_s p_{s,t-1}$, i.e., does not display error-correcting behaviour, but $\Delta p_{rt}$ does, because otherwise rank($\Pi$) = 0 implying that there is no cointegration (in fact, cointegration implies error-correction and the other way round). This result is in favour of retailer dominance. If the retailer does not dominate, then both $\alpha_s$ and $\alpha_r$ are unequal to zero such that both prices are error-correcting.

## RESULTS

Here, an empirical application of the procedure outlined in the previous section is presented. Two food products are considered at industry level: 1. potatoes and potato products (potatoes for short), and 2. processed coffee. In the case of potatoes there are no strong A-brands and there is not much room for suppliers to set their prices as if they were a monopolist. Coffee, however, has some strong A-brands, in particular Douwe Egberts with a market share of 73% (Heijbroek and Schoemaker, 1993: 35). Here, as part of their marketing strategy suppliers are able to manipulate prices in order to influence consumer demand. Consequently, if the suppliers have some power vis á vis the retailers, then this could be expected to be the case for coffee, but is less conceivable for potatoes.

Our sample consists of monthly wholesale and consumer price indices (1990 = 100) which are obtained from Statistics Netherlands. For potatoes data are used from January 1991 up to and including September 1997 (81 observations). The sample for coffee runs from January 1992 up to and including September 1997 (69 observations). Inflation can be ignored when compared to the stochastic trend movements in the prices. Hence, the price series were not deflated.

First, a general form of model (14) was specified in which no restrictions were imposed on the parameters of $p_{r,t-1}$ and $p_{s,t-1}$. After some model selection without allowing the intercept, $p_{r,t-1}$ and $p_{p,t-1}$ to be deleted from the equations, the variable $\Delta p_{r,t-12}$ was kept in the price equations for potatoes and $\Delta p_{s,t-1}$ was left in the price equations for coffee. Using these models, the Johansen procedure was applied to compute the trace statistics in order to determine the rank of $\Pi$. Because the critical values of the trace test depend on the specification of the deterministic part of the VECM, we first had to decide whether or not the intercept is restricted to be only included in the cointegration equation. The graphs of the retail and wholesale prices of both potatoes and coffee showed an upward movement. Consequently, the intercept was not restricted. The trace statistics and their critical values are presented in Table 1.

Table 1. Johansen cointegration test

| | Potatoes | |
|---|---|---|
| rank($\Pi$) | trace statistic | 5% critical value[1] |
| 0 | 15.90* | 15.41 |
| 1 | 3.01 | 3.76 |
| | Coffee | |
| rank($\Pi$) | trace statistic | 5% critical value[1] |
| 0 | 30.02* | 15.41 |
| 1 | 2.44 | 3.76 |

[1] Critical values are obtained from Table 1 in Osterwald-Lenum (1992: 468)

For both products the trace statistics in Table 1 show that rank($\Pi$) = 0 must be rejected, whereas rank($\Pi$) = 1 cannot be rejected. These results indicate that the retail price and the wholesale price are cointegrated, at least, if their coefficients are significant. They are.

The cointegrating relation for potatoes was found to be

$$p_{rp,t} = 0.47\, p_{sp,t} + 59.29 + \hat{e}_{rp,t}, \tag{15}$$

where $p_{rp,t}$ is the retail price of potatoes, $p_{sp,t}$ is the wholesale price of potatoes and $\hat{e}_{rp,t}$ is the equilibrium error. The coefficient of the wholesale price has a positive sign. This complies with the theoretical model. From the estimated parameter values it can be derived that a considerable part of the retail margin is absolute, at least, if it is true that the measurement units of the retail and wholesale prices are more or less the same.

The cointegrating relation for coffee appeared to be

$$p_{rc,t} = 1.08\, p_{sc,t} + 5.02 + \hat{e}_{rc,t}\,, \tag{16}$$

where $p_{rc,t}$ is the retail price of coffee, $p_{sc,t}$ is the wholesale price of coffee and $\hat{e}_{rc,t}$ is the equilibrium error. At the 2.5 percent level the coefficient of $p_{sc,t}$ is not significantly different from one and the intercept can be restricted to zero. From these results it can be derived that the retail margin tends to be a percentage markup over the wholesale price.

To study the error-correcting behaviour, we now consider the parameter estimates in the VECM equations.

For potatoes, the estimated model for the retail price is given by ($t$ statistics in parentheses)

$$\hat{}\Delta p_{rp,t} = -0.11 - 0.20\,\hat{e}_{rp,t-1} + 0.15\,\Delta p_{rp,t-1} + 0.46\,\Delta p_{sp,t-1} + 0.45\,\Delta p_{rp,t-12} + \varepsilon_{rp,t}\,, \tag{17}$$

(−0.11) (−3.31) (1.38) (1.72) (4.73)

$T = 68$; $R^2 = 0.36$; $\sigma = 5.74$; $DW = 2.02$; *prob.* $AR1\text{-}1 = 0.87$; *prob.* $AR1\text{-}4 = 0.88$,

and the estimated equation for the wholesale price was found to be

$$\hat{}\Delta p_{sp,t} = 0.16 + 0.01\,\hat{e}_{rp,t-1} + 0.03\,\Delta p_{rp,t-1} + 0.19\,\Delta p_{sp,t-1} + 0.07\,\Delta p_{rp,t-12} + \varepsilon_{sp,t}\,, \tag{18}$$

(−0.11) (0.47) (0.47) (1.42) (1.49)

$T = 68$; $R^2 = 0.09$; $\sigma = 2.85$; $DW = 1.94$; *prob.* $AR1\text{-}1 = 0.74$; *prob.* $AR1\text{-}4 = 0.40$,

where *prop.* $AR1\text{-}i$ is the $p$-value of the $F$ version of the LM statistic testing for the absence of $i$th-order autocorrelation in the estimated residuals. The coefficient of the error-correction term,
$\hat{e}_{rp,t-1}$, is −0.20 and significant in (17), but is not significant in (18). Consequently, we conclude that the wholesale price does not display error-correcting behaviour and therefore, we reject the model in which the supplier is able to use foresight in favour of the model in which the retail market does not allow suppliers to control prices.

For coffee, the estimated model for the retail price is given by

$$\Delta \hat{p}_{rc,t} = 0.21 - 0.38\,\hat{e}_{rc,t-1} + 0.81\,\Delta p_{sc,t-1} + \varepsilon_{rc,t}\,, \tag{19}$$

(0.53) (−2.41) (7.70)

$T = 69$; $R^2 = 0.52$; $\sigma = 3.19$; $DW = 2.11$; *prob.* $AR1\text{-}1 = 0.54$; *prob.* $AR1\text{-}4 = 0.60$,

and the estimated equation for the wholesale price was found to be

$$\Delta p_{sc,t} = 0.34 + \underset{(0.92)}{0.26}\,\hat{e}_{rc,t-1} + \underset{(1.76)}{0.60}\,\Delta p_{sc,t-1} + \underset{(6.09)}{\varepsilon_{sc,t}}, \qquad (20)$$

$T = 69$; $R^2 = 0.37$; $\sigma = 3.01$; $DW = 2.00$; $prob.\ AR1\text{-}1 = 0.99$; $prob.\ AR1\text{-}4 = 0.52$.

The error-correction term, $\hat{e}_{rc,t-1}$, significantly enters both equations (19) and (20) when compared with the 5 percent critical value of the one-side $t$ test. The estimated values of the parameters of $\hat{e}_{rc,t-1}$ imply error-correcting behaviour of both prices. As a consequence, we conclude that the suppliers of coffee products have some influence in setting consumer prices to maximise their profits.

## CONCLUSION

In this study the method of cointegration was applied to discriminate between two channel regimes. In the first regime the suppliers have enough power vis-á-vis the retailers to be involved in setting the consumer price. In the second regime the suppliers set their prices only on the basis of their costs (including those of raw materials) without being able to choose their prices on the basis of consumer demand.

To investigate which regime applies, a test procedure was developed on the basis of cointegration and error-correction analysis. The procedure can already be used if time-series data on the wholesale price and the retail price of the product are available.

In the empirical analysis the test procedure was applied to two food product groups in the Dutch market: potato products and processed coffee. With respect to potato products we knew that suppliers had not been able to monopolize the market by an effective marketing policy. In the case of coffee, however, there are some strong A-brands in the market allowing suppliers to choose prices that fit into their marketing strategy.

The empirical results confirm our observations. In the case of potatoes it was found that in the long run wholesale prices are only based on suppliers' costs, while in the case of coffee wholesale prices are also based on consumer demand.

In this paper we limited our attention to a single-supplier, single-retailer channel dealing with a single product. Extensions to more general models of channels with more than two stages and more than one agent per stage is clearly required for in order to obtain a more explicit understanding of pricing decisions in a marketing channel.

## REFERENCES


1. Banerjee, A., J.J. Dolado, J.W. Galbraith, and D.F. Hendry. 1993. *Co-integration, error-correction, and the econometric analysis of non-stationary data*, Oxford University Press, Oxford, 329 pp.
2. Choi, S.C. 1996. Price competition in a duopoly common retailer channel. *Journal of Retailing* 72(2): 117-134.
3. Engle, R.F. and C.W.J. Granger. 1987. Cointegration and error correction: representation estimation, and testing. *Econometrica* 55(2): 251-276.
4. Gonzalo, J. and C. Granger. 1995. Estimation of common long-memory components in cointegrated systems. *Journal of Business & Economic Statistics* 13(1): 27-35.
5. Granger, C.W.J. and J.-L. Lin. 1995. Causality in the long run. *Econometric Theory* 11: 530-536.

6. Granger, C.W.J. and P. Newbold. 1986. *Forecasting economic time series*, Second Edition, Academic Press, Orlando, 338 pp.
7. Heijbroek, A.M.A. and M.J. Schoemaker. 1993. *The world coffee market*, Rabobank Nederland, 48 pp.
8. Johansen, S. 1995. *Likelihood-based inference in cointegrated vector autoregressive models*, Oxford University Press, Oxford, 267 pp.
9. Johansen, S. and K. Juselius. 1990. Maximum likelihood estimation and inference on cointegration - with applications to the demand for money. *Oxford Bulletin of Economics and Statistics* 52(2): 169-210.
10. Lee, E. and R. Staelin. 1997. Vertical strategic interaction: implications for channel pricing strategy. *Marketing Science* 16(3): 185-207.
11. Osterwald-Lenum, M. 1992. A note with quantiles of the asymptotic distribution of the maximum likelihood cointegration rank test statistics. *Oxford Bulletin of Economics and Statistics* 54(3): 461-471.
12. Tirole, J. 1988. *The theory of industrial organization*, The MIT Press, Cambridge (Mass.), 479 pp.
13. Von Ungern-Sternberg, T. 1994. Percentage retail mark-ups. Cahier no 9412. DEEP, University of Lausanne.