

Appendix

In this appendix we show that the optimal degree of profit sharing in the backward contract is on the interval $(0,1]$. We do this in two parts. We first show the optimal contractual share to be non-negative. Assume the share is not positive. From expression (14), $\alpha^* \leq 0$ implies:

$$c - Pf_D' - P' f_D' f_D \leq P' f_F' f_D \left(\frac{\partial x_F}{\partial x_D} \right).$$

Rearranging terms, we can express this result as:

$$c \leq Pf_D' + P' f_D' f_D + P' f_F' f_D \left(\frac{\partial x_F}{\partial x_D} \right) = P^U$$

where the right-hand equality holds by the downstream first-order condition (13).

The non-positive profit-share contradicts the optimal price set in the upstage industry, however, as $c > P^U$ by expression (12). Therefore, non-positive market-share contracts contradict, whence the market-share of an upstream producer is positive.

We next show the optimal contractual share to be consistent with values less than one. From expression (15), a contractual share less than unitary value implies:

$$c - Pf_D' - P' f_D' f_D < 2P' f_F' f_D \left(\frac{\partial x_F}{\partial x_D} \right),$$

or, using downstream first-order condition (16), that:

$$c - P^U < P' f_F' f_D \left(\frac{\partial x_F}{\partial x_D} \right) \tag{A1}$$

The claim holds for any α by inspection, since all values of $\alpha < 1$ that satisfy the upstream optimality condition (12), $c - P^U = \alpha P' f_F' f_D \left(\frac{\partial x_F}{\partial x_D} \right)$, also satisfy condition (A1). Q.E.D.

7. A Structural Vector Error-Correction Model of Price Time Series to Detect Bottleneck Stages within a Marketing Channel

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1 Introduction

Bottlenecks in the food chain can result from shortcomings in market transparency and in the capacity or willingness to adapt to market changes. Shortcomings in market transparency may originate from poor exchange of market information and from limited transfer of changes in prices through the channel.

This paper is concerned with bottlenecks in the coordination of marketing policies in the channel of agricultural and food products. We focus on price coordination. This subject has been fundamentally discussed in the industrial economics theory (e.g. Tirole, 1988; Martin, 1993). The relationship between farm prices and consumer food prices has been extensively investigated in the vast literature on marketing margins (Berck and Rauser, 1982; Briz and De Felipe, 1997).

This paper tackles a specific topic in this field. It tries to develop a method for monitoring the quality of price coordination in agricultural marketing channels. Such methods seem indispensable for finding shortcomings in channel performance.

The paper is organized as follows. In Section 2 a conceptual framework for price relationships in food marketing channels is developed. In Section 3 vector error-correction modelling is proposed as a measurement instrument for monitoring price coordination in the food chain. In Section 4 this instrument is applied to the pork production-marketing chain in the Netherlands. In Section 5 the main conclusions are summarized and directions for further research are proposed.

2 Models

Price coordination in marketing channels is concerned with relating product prices at various stages of the marketing channel in such a way that

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the channel is performing well. It implies that product price changes at a particular stage of the channel, *ceteris paribus*, influence prices in other stages of the marketing channel. The correlation between prices at the different stages of the marketing channel seems an important indicator of price coordination or bottlenecks in marketing channels, but does not tell the whole story. In fact, price coordination in the channel depends on the price strategy of the respective channel companies. Therefore, monitoring a marketing channel for price bottlenecks might profit from a conceptual framework of companies' price strategy vis á vis changing purchase prices. We suggest the following hierarchy in price coordination as a framework for monitoring bottlenecks in pricing. As a matter of convenience, we assume in our presentation a three-level marketing channel, e.g. producer, wholesaler and retailer, referred to as companies 1, 2 and 3 respectively, but our results can be generalized to a p -level channel.

“*Ad hoc*” price coordination”, price changes are coordinated only in case of substantial price changes.

In this situation companies fix their price without considering “modest” price changes by other companies in the channel:

$$p_i = p_{i,s} + u_i, \quad (1a)$$

$$u_i = N(0, \sigma_i^2), \quad (1b)$$

where p_i is the selling price of company i ($i = 1, 2, 3$), $p_{i,s}$ is the structural price of company i and u_i is a random term.

Companies have a price, $p_{i,s}$, in mind which they consider to be appropriate in view of the structural demand. Actual prices deviate from that price only by a random term. Company i does not change its selling price p_i vis á vis changes in the purchase price p_{i-1} . This case of absent price coordination in the channel seems relevant only in stationary markets or when the price p_{i-1} is a minor part of total costs per unit of company i , for example, in case of substantial processing of agricultural products. However, in dynamic markets purchase prices might change substantially and companies might use the additional criterion:

$$p_i - p_{i-1} > m_i, \quad (1c)$$

where m_i is the necessary contribution of p_i to variable costs and overhead per unit of product. In case of substantial price changes this condition will

often not be fulfilled and company i may now change its selling price in response to changes in the purchase price.

“Routinized price coordination”, systematic price coordination by companies in the channel on the basis of a routine procedure.

Two situations can be distinguished:

- a) Companies apply the same “markup” as a routine procedure;
- b) “Follow the leader” as a price coordination procedure.

a)

Company i in the channel is using a specific markup as a routine procedure:

$$p_i = f(p_{i-1}, x_i) , \quad (2a)$$

where x_i are other price-influencing factors. This routine procedure, for example $p_i = \alpha_0 + \alpha_1 p_{i-1}$ or $p_i = \alpha p_{i-1}$, may have an economic basis, but cannot always be considered to be a rational, optimizing procedure. In markets with frequent, e.g. daily, price changes, transaction costs of economically effective pricing per transaction might be too high. For that reason, companies use a routine procedure, which has proven to be economically viable. Such a procedure may be practised, for instance, by wholesalers and retailers in marketing channels of fresh produce.

b)

Companies adapt prices to changes in prices of the channel leader:

$$p_i = f(p_{cl}, x_i) , \quad (3)$$

where p_{cl} is the price of the channel leader. For instance, in consumer-oriented marketing channels big retailers or food industries may initiate a price change if consumer demand is decreasing or increasing. Other companies in the channel will follow.

“Rational price coordination”, coordination of channel prices aiming at profit maximization.

Also here two models can be distinguished:

- a) partially rational price coordination;
- b) fully rational price coordination.

a)

Individual companies in the channel, but not the channel as a whole, adapt prices to changes in purchase prices in order to maximize profit:

$$\text{Max } \Pi_i = (p_i - c_i - p_{i-1})q, \quad (4a)$$

subject to

$$\ln p_3 = (1/\delta_p) \ln q + s, \quad (\delta_p < -1) \quad (4b)$$

where Π_i is the profit of company i , q is the product flow through the channel and c_i are the costs per unit faced by company i . The inverse demand equation (4b) is assumed to be log-linear so the price elasticity of demand, δ_p , is constant. s captures exogenous demand shifts. Π_3 will be maximized if:

$$\partial \Pi_3 / \partial q = p_3 + q(\partial p_3 / \partial q) - c_3 - p_2 = 0, \quad (4c)$$

leading to the following price equilibrium:

$$p_3 = (p_2 + c_3) \delta_p / (1 + \delta_p). \quad (4d)$$

Subject to (4d) the first-order condition with respect to maximization of Π_2 gives

$$p_2 = p_1 \delta_p / (1 + \delta_p) + (\delta_p c_2 - c_3) / (1 + \delta_p), \quad (4e)$$

and finally, reminding that $\Pi_1 = (p_1 - c_1)q$, maximization of Π_1 determines p_3 :

$$p_3 = \sum_{i=1}^3 c_i [\delta_p / (1 + \delta_p)]^3. \quad (4f)$$

From (4f) and (4b) q can be derived.

b)

The companies determine jointly the price of the final channel product such that profits are maximized. This implies:

$$\text{Max } \Pi_C = (p_c - \sum_{i=1}^3 c_i)q, \quad (5a)$$

subject to

$$\ln p_c = (1/\delta_p) \ln q + s, \quad (\delta_p < -1) \quad (5b)$$

where Π_c is the profit of the whole channel and p_c is the price of the final channel product. The first-order condition of the profit maximization problem is:

$$\partial \Pi_c / \partial q = p_c + q(\partial p_c / \partial q) - \sum_{i=1}^3 c_i = 0, \quad (5c)$$

giving

$$p_c = \sum_{i=1}^3 c_i \delta_p / (1 + \delta_p). \quad (5d)$$

Because $\delta_p < -1$, comparing (4f) with (5d) shows that $p_c < p_3$ and hence, q will be greater at p_c than at p_3 and so Π_c will be greater than $\Pi_1 + \Pi_2 + \Pi_3$ of the partially rational price coordination model.

Equilibrium price relationships can be derived e.g. by assuming that companies 1 and 2 charge a two-part tariff (Tirole, 1988: 176):

$$p_i q = A_i + \sum_{j=1}^i c_j q. \quad (5e)$$

From (5a) it follows that

$$p_c = \Pi_c / q + \sum_{j=1}^3 c_j, \quad (5f)$$

so company 2 charges company 3

$$p_2 = \alpha_2 \Pi_c / q + c_1 + c_2 = \alpha_2 (p_c - \sum_{j=1}^3 c_j) + c_1 + c_2, \quad (5g)$$

with $0 \leq \alpha_2 \leq 1$, and, in turn, company 1 charges company 2

$$p_1 = \alpha_1 \alpha_2 \Pi_c / q + c_1 = \alpha_1 (p_2 - c_1 - c_2) + c_1, \quad (5h)$$

with $0 \leq \alpha_1 \leq 1$. From (5g) and (5h) it can be seen that company 2 takes α_2 part of Π_c away from company 3, while company 1 takes α_1 part of $\alpha_2 \Pi_c$ away from company 2. The companies have to agree upon feasible values of α_1 and α_2 .

The proposed hierarchy from “*ad hoc*” price coordination”, “*routinized price coordination*” to “*rational price coordination*” suggests that the more rational companies are, the more price coordination is grounded on economic factors such as costs and price elasticity of demand. Nevertheless, all models suggest quite the same bivariate equilibrium (i.e., static) price relationships. Therefore, in addition to studying the static price relationships, as e.g. in

Larue (1991), we must also consider short-run price dynamics that shows how these equilibrium price relationships are affected and reestablished after a price shock (innovation) occurs in one of the channel stages. In the next sections this investigation will be carried out by vector error-correction modelling and applied to the Dutch pork production-marketing chain.

3 Method

Let $X_t = (p_{1t}, \dots, p_{pt})'$ be a vector of p prices, where p_{it} ($i = 1, \dots, p$) is the output price of stage i in the marketing channel and $p \geq 2$ is the total number of stages in the marketing channel in which stage 1 is upstream and stage p is downstream. Given that u_{it} is integrated of order zero (i.e., stationary), denoted $I(0)$, while the prices, like many economic variables, are integrated of order one (i.e., nonstationary), denoted $I(1)$, see e.g. Hamilton (1994), all models in Section 2 imply $p - 1$ bivariate long-run equilibrium price relationships as follows:

$$p_{it} = \beta_{0,i-1} + \beta_{1,i-1} p_{i-1,t} + e_{it}, \quad (6)$$

where $i = 2, \dots, p$, the β 's are parameters and e_{it} is $I(0)$ representing the short-run deviations from the equilibrium. A multivariate time series model must be used to find evidence of (6) and to show how prices respond if one of them causes a disequilibrium. In this study we employ Johansen's maximum likelihood (ML) procedure (Johansen, 1988, 1991 and 1995b; Johansen and Juselius, 1990, 1994) for estimation of a vector error-correction model (VECM) of the prices.

Starting point of the Johansen procedure is a vector autoregressive model of order k , denoted VAR(k), that can be rewritten as

$$\Delta X_t = \Pi X_{t-1} + \sum_{j=1}^{k-1} \Gamma_j \Delta X_{t-j} + \mu + \Phi D_t + \varepsilon_t, \quad (7)$$

where $\Delta X_t = X_t - X_{t-1}$, μ are the intercepts, D_t are centred seasonal dummies which sum to zero over a full year, $\varepsilon_1, \dots, \varepsilon_T$ are $IIN_p(0, \Lambda)$ and X_{-k+1}, \dots, X_0 are fixed. Suppose that X_t is $I(1)$, then the coefficient matrix Π contains information about the long-run price relationships. If $\text{rank}(\Pi) = r$ with $0 < r < p$, then there are r long-run (i.e., cointegration) relationships and Π can be expressed as the outer product of two (full column rank) ($p \times r$) matrices α and β :

$$\Pi = \alpha\beta', \quad (8)$$

such that β/X_t is $I(0)$ in which case (7) is called a VECM. The columns of β are called the cointegrating vectors and can be identified by imposing restrictions as follows:

$$\beta = (H_1\phi_1, \dots, H_r\phi_r), \quad (9)$$

where H_j ($j = 1, \dots, r$) is a $(p \times s_j)$ matrix reducing the p -dimensional vector β_j to the s_j -dimensional vector ϕ_j with $2 < s_j < p$. The system is checked for identification using the rank condition in Johansen (1995a) and the ML estimates of α and β are computed by the switching algorithm outlined in Johansen and Juselius (1994).

If prices are coordinated such that there are $p - 1$ cointegrating vectors, then none of the stages act as bottlenecks in long-run price coordination. Moreover, if the i th row of α is zero, i.e., p_{it} is weakly exogenous for β (Johansen, 1992a,b), then, following Hall and Milne's (1994) definition of long-run causality, stage i is the channel price leader. There are no channel price leaders if α does not contain zero rows.

A stage will be considered a bottleneck in short-run price coordination if its price does not transfer price changes in the chain. These bottlenecks can be traced by estimating (7) under the restrictions (8) and (9), and using this estimated model, while abstracting from D_t , to simulate the prices after one price has broken the equilibrium.

An empirical application is presented in the next section.

4 Application

We consider the marketing channel of pork in the Netherlands, see, for example, Den Ouden et al. (1996). Four stages are distinguished ($p = 4$): the breeders (stage 1), who produce the piglets; the fatteners (stage 2), who produce the fattened pigs; the slaughterhouses (stage 3), which produce the pork; and lastly, the retailers (stage 4), who sell the pork to the consumers. Consequently, the dataset contains the piglet price, p_1 (Dfl/piglet), the price of fattened pigs, p_2 (Dfl/100kg), the price index of pork at the slaughterhouse level, p_3 (1985 = 100), and the retail price index of pork, p_4 (1985 = 100). All prices are deflated by the Dutch consumer price index (1985 = 1.00). Our sample consists of monthly data from January 1989 up to and including May 1994 (65 observations). The data and their sources are available from the authors upon request.

First, the order of the VAR, k , is determined as well as the number of cointegrating vectors, r , see Table 1. Four information criteria are computed: FPE, AIC, HQ and SC, see Lütkepohl (1991). The estimate for k is chosen

such that the criterion is minimized. FPE and AIC select $k = 2$, while HQ and SC estimate $k = 1$. However, at $k = 1$ the likelihood ratio test testing 16 restrictions, denoted LR(16), rejects VAR(1) against VAR(2) at the 10% level. Moreover, a VAR(2) complies with $p - 1 = 3$ cointegrating vectors as selected by Johansen's trace statistic (see Table 2), where we use those 90% quantiles, denoted trace(90%), that comply with the result that the LR(1) test (see Table 1) does not reject the restriction according to which μ is only included in the cointegrating space (for the LR test concerning μ , see Johansen and Juselius, 1990; the critical values are obtained from Table 1* in Osterwald-Lenum, 1992: 467). Based on these results we tentatively conclude that $k = 2$ and $r = 3$.

Table 1. VAR order determination

| k | 0 | 1 | 2 | 3 | 4 | 5 |
|-------------------|------|-------|-------|-------|-------|--------|
| FPE | 3802 | 34.64 | 33.11 | 42.74 | 64.13 | 115.44 |
| AIC | 6.53 | 1.80 | 1.69 | 1.85 | 2.11 | 2.48 |
| HQ | 6.53 | 2.02 | 2.14 | 2.52 | 3.00 | 3.59 |
| SC | 6.53 | 2.37 | 2.84 | 3.57 | 4.40 | 5.52 |
| p -value LR(16) | 0.00 | 0.07 | 0.65 | 0.92 | 0.99 | 0.21 |
| r | | 2 | 3 | 1 | 0 | 0 |
| p -value LR(1) | | 0.79 | 0.96 | 0.54 | 0.67 | 0.47 |

Table 2. Cointegrating rank determination ($k = 2$)

| r | 0 | 1 | 2 | 3 |
|------------|-------|-------|-------|------|
| trace | 71.93 | 39.01 | 19.42 | 3.77 |
| trace(90%) | 49.65 | 32.00 | 17.85 | 7.52 |

The $r = p - 1 = 3$ result is in line with the price coordination models discussed in Section 2. After normalization, the estimated cointegrating vectors lead to the following long-run equilibrium price relationships (t -values in parentheses are asymptotically $N(0,1)$ distributed):

$$p_{2t} = 55.98 + 2.13p_{1t} + \hat{e}_{2t}, \quad (10a)$$

(4.64) (10.21)

$$p_{3t} = 15.68 + 0.19p_{2t} + \hat{e}_{3t}, \quad (10b)$$

(16.02) (35.33)

$$p_{4t} = 3.85 + 0.05p_{3t} + \hat{e}_{4t}. \quad (10c)$$

(12.95) (20.20)

All cointegrating parameter estimates are highly significant and have the correct sign. Hence, as far as this limited evidence goes, we conclude that there are no bottlenecks in long-run price coordination.

To investigate the short-run dynamics, the response to a one-time one-standard deviation shock (i.e., impulse) in one of the prices is computed. Following the observed chronology in the pork production-marketing chain, the Δp_{it} variable(s) is (are) added to the Δp_{jt} equation of the VECM ($i = 1, \dots, j - 1$ for each $j = 2, 3, 4$) (cf. Sanjuan et al., 1997). This extension, which, in fact, proposes a (recursive) structural VECM (Hamilton, 1994: 324-340), is necessary in order to avoid misleading results emerging from erroneously ignoring the contemporaneous correlation among the disturbances of the VECM. Tables 3-6 show how the prices respond to an impulse in p_i in, say, month 0. The responses are computed in terms of deviations (%) from the equilibrium values in month -1. Responses marked with an "*" are significant when using a 95% confidence interval.

In Tables 3 and 6 the effect of the impulse to the system appears to be permanent and as predicted by the long-run structure (10a)-(10c), all prices change in the same direction to reach their new equilibrium values, which are higher than the old ones in case of an impulse in p_1 and lower after an impulse in p_4 . Moreover, the more down-stream a stage is, the less the price changes. This result is in line with the price coefficients in the long-run relationships of the partially rational price coordination model, see equations (4d) and (4e).

Table 3. Deviation (in %) from the long-run equilibrium value in month -1 as a consequence of an impulse in p_1 (1)

| month | p_1 | p_2 | p_3 | p_4 |
|----------|--------|-------|-------|-------|
| 0 | 6.89* | 2.86* | 1.56* | -0.29 |
| 1 | 7.46* | 3.58* | 1.78* | -0.24 |
| 2 | 8.03* | 4.29* | 2.38* | 0.54* |
| 3 | 8.30* | 4.89* | 2.20* | 0.74* |
| 4 | 8.66* | 5.39* | 3.39* | 1.00* |
| 5 | 9.13* | 5.87* | 3.78* | 1.21* |
| 10 | 10.25* | 6.53* | 4.33* | 1.67* |
| 20 | 10.02* | 6.08* | 4.00* | 1.52* |
| 30 | 10.02* | 6.12* | 4.03* | 1.53* |
| ∞ | 10.02* | 6.12* | 4.02* | 1.53* |

(1) Values marked with an "*" are significant at the 2.5% level.

Table 4. Deviation (in %) from the long-run equilibrium value in month -1 as a consequence of an impulse in p_2 (1)

| month | p_1 | p_2 | p_3 | p_4 |
|----------|-------|-------|-------|-------|
| 0 | 0 | 3.94* | 2.41* | 0.72* |
| 1 | 0.07 | 3.74* | 2.51* | 1.10* |
| 2 | 0.11 | 2.94* | 2.28* | 1.26* |
| 3 | 0.01 | 2.15 | 1.85* | 1.14* |
| 4 | -0.28 | 1.26 | 1.25 | 0.96* |
| 5 | -0.67 | 0.42 | 0.62 | 0.70 |
| 10 | -3.10 | -2.27 | -1.46 | -0.45 |
| 20 | -3.41 | -2.06 | -1.36 | -0.53 |
| 30 | -3.33 | -2.04 | -1.34 | -0.51 |
| ∞ | -3.34 | -2.04 | -1.34 | -0.51 |

(1) Values marked with an "*" are significant at the 2.5% level.

Table 5. Deviation (in %) from the long-run equilibrium value in month -1 as a consequence of an impulse in p_3 (1)

| month | p_1 | p_2 | p_3 | p_4 |
|----------|-------|-------|-------|-------|
| 0 | 0 | 0 | 1.24* | 0.28 |
| 1 | 2.16* | 2.06* | 2.06* | 0.17 |
| 2 | 3.83* | 2.87* | 2.13* | 0.77* |
| 3 | 4.88* | 3.30* | 2.14* | 0.85* |
| 4 | 4.85* | 3.10* | 1.96* | 0.86* |
| 5 | 4.58* | 2.83* | 1.83* | 0.79* |
| 10 | 4.10 | 2.47 | 1.63 | 0.63 |
| 20 | 4.08 | 2.49 | 1.64 | 0.62 |
| 30 | 4.09 | 2.50 | 1.64 | 0.63 |
| ∞ | 4.09 | 2.50 | 1.64 | 0.63 |

(1) Values marked with an "*" are significant at the 2.5% level.

In Tables 4 and 5, however, the impulse to the system does not lead to responses that are significant in the long run. Nevertheless, according to Table 4, in the short run the impulse in p_2 does bring about significant changes in the prices of the subsequent stages, but not in p_1 . Apparently, an impulse in the price of fattened pigs has no significant effect on piglet prices. Consequently, stage 1 is a bottleneck in case of an impulse in p_2 . Finally, no bottlenecks are found in Table 5, because in the short run all prices show significant responses to the impulse in p_3 .

In addition to monitoring price bottlenecks, α is tested for zero rows to

detect which stage is the price leader. The results are presented in Table 7. When using the 10% significance level, it appears that all prices are error-correcting. Therefore, we tentatively conclude that there is no stage whose price is driving the prices of the other stages in the long run, implying that there is no stage that can be considered the price leader.

Table 6. Deviation (in %) from the long-run equilibrium value in month -1 as a consequence of an impulse in p_4 (1)

| month | p_1 | p_2 | p_3 | p_4 |
|----------|--------|--------|--------|--------|
| 0 | 0 | 0 | 0 | 1.85* |
| 1 | -1.07 | -0.40 | -0.58 | 0.08 |
| 2 | -3.99* | -2.81* | -1.82* | 0.02 |
| 3 | -4.96* | -3.48* | -2.13* | -0.57* |
| 4 | -5.74* | -3.97* | -2.47* | -0.79* |
| 5 | -5.95* | -4.10* | -2.62* | -0.92* |
| 10 | -6.26* | -3.97* | -2.65* | -1.06* |
| 20 | -5.92* | -3.59* | -2.36* | -0.90* |
| 30 | -5.94* | -3.63* | -2.39* | -0.91* |
| ∞ | -5.94* | -3.63* | -2.39* | -0.91* |

(1) Values marked with an "*" are significant at the 2.5% level.

Table 7. Testing for the absence of the error-correction terms in the equations of the (non-structural) VECM

| test statistic | equation of | | | |
|----------------|-----------------|-----------------|-----------------|-----------------|
| | Δp_{1t} | Δp_{2t} | Δp_{3t} | Δp_{4t} |
| $F(3,44)$ | 2.88 | 4.73 | 2.45 | 9.52 |
| p -value | 0.04 | 0.01 | 0.08 | 0.00 |

5 Conclusions

In this paper we proposed a method for monitoring bottlenecks in price coordination within the chain. We applied our method to analysing price coordination in the Dutch pork production-marketing chain. Starting with the upstream one, the following four stages were considered: the breeders (stage 1), who produce the piglets; the fatteners (stage 2), who produce the fattened pigs; the slaughterhouses (stage 3), which produce the pork; and lastly, the retailers (stage 4), who sell the pork to the consumers. The main conclusions are:

- The proposed framework and research methodology seem to be a useful instrument for monitoring price bottlenecks in agricultural marketing channels, in particular for products that are processed to a minor extent in the channel, such as fresh products like pork.
- In the pork chain there are no structural bottlenecks in price coordination, i.e., in the long run the output price in each stage forms an equilibrium relationship with each of the output prices of the other stages.
- None of the stages appear to be the price leader in the sense of driving the prices in the other stages in the long run.
- In the long run, the more downstream a stage is, the less its price differs from the equilibrium value that had been reached before a one-time price shock occurred in one of the stages of the pork chain.
- In the short run the price of piglets does not respond to price changes in other stages if these price changes are initiated by an impulse in the price of fattened pigs. Hence, in case of an impulse in the price of fattened pigs the breeders act as bottlenecks in short-run price coordination.

Our analysis of bottlenecks can be extended along the framework proposed in Section 2 by analysing the long-run equilibrium price relationships in more detail, by introducing more variables, such as competitive prices, and by allowing for more than one firm per stage of the marketing channel (see e.g. Choi, 1996, and Wohlgenant, 1989, and the references cited therein). All these extensions, however, ask for a further elaboration of demand and cost functions.

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