A METHOD TO DETECT BOTTLE-NECK STAGES WITHIN A MARKETING CHANNEL

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1. Introduction

One of the central themes in the current National Debate on new strategies for Dutch agriculture is the shift from volume to quality, i.e. from producing at the lowest cost to producing products that fit the needs and wants of target groups of consumers (Van der Ploeg et al.[1]). This market-driven strategy, however, is not new. Its necessity has been recognized for a long time. However, the implementation of such a consumer orientated system is not easy. Many firms are involved in the implementation process. They can be categorized into two or more successive stages of the agricultural marketing channel, managing the flow of agricultural goods through the entire value-added chain (Meulenberg and Kool[2]). Consequently, if firms in at least one of the stages are not able or willing to participate in the consumer orientation strategy, then the whole channel might be hindered in adopting such a strategy.

For example, in Western economies, like the Dutch one, the primary production of agricultural goods is taking place at a large number of small farms such that each farm is a price-taker. Hence, to maximize its income the farming family has to minimize its costs. For this purpose, farmers continually apply new production technology that decreases production cost per unit output by increasing productivity. Moreover, farmers accept lower incomes than the average wage when employed in other sectors, simply because each farming family wants to stay on its own farm (De Hoogh[3]). Consequently, the farmer spends all his efforts producing as efficiently as possible; no time seems to be left to monitor the changing needs of consumers. Therefore, it could be that farmers will not adopt a market-driven strategy. As a consequence, they cause a bottle-neck in the marketing channel when other channel members, like retail companies, wholesalers and processing industries, introduce a consumer-oriented policy.

Bottle-necks may concern different types of problems such as in the field of channel efficiency and -effectiveness, and are often difficult to characterize. Nevertheless, ultimately all bottle-necks have an impact on the profits per unit output and in this paper we will use this fact in developing a method to identify bottle-neck stages within a marketing channel. An empirical application of this method to the marketing channel of pork in the Netherlands will also be provided.

This paper is organized as follows: In section 2 we outline our definition and method of detecting bottle-neck stages. In section 3 the formal test procedure is briefly addressed. In section 4 we present our empirical results. In section 5 conclusions round off the paper.

2. Method

Bottle-neck stages within a marketing channel imply inappropriate responses by companies at some stage of the marketing channel to policy-changes and -outcomes at other stages of the marketing channel, and vice versa. Lack of responsiveness of companies within the marketing channel may concern total marketing policy, say the introduction of a new product at some stage in the channel, or a specific element of a marketing policy, e.g. the logistical operation. Such bottle-necks may arise from insufficient market orientation or from poor coordination mechanisms by chain members or from both. It is important to trace bottle-necks to manage chains effectively and efficiently. Methods testing for bottle-necks differ depending upon the type of bottle-neck one is searching for. For instance, testing for bottle-necks in logistical operations requires a different testing procedure as compared to testing for bottle-necks in communication. Nevertheless, ultimately all bottle-necks affect the profit per unit output, margin, say. Hence, the evolvement of a margin through time for a channel stage relative to the evolvement of the margins through time for other stages may be considered as an indicator of bottle-necks. Moreover, the lack of responsiveness of companies at one stage of the channel to changes in prices, margins and profits at other stages of the channel is also an important set of potential bottle-necks in marketing channels themselves. Therefore, we propose a statistical method to trace such bottle-necks and have applied this method to the Dutch pork channel.

Before we give a more specific definition of bottle-neck for our problem, we will first discuss the analytical framework. This framework is based on the Law of One Price (LOP). According to Goodwin [4] the "LOP asserts that efficient trade and arbitrage activities will ensure that prices in spatially separated markets, once adjusted for exchange rates and transportation costs, will be equalized. Assuming absolute adherence to the LOP allows the definition of a single "representative price" common to all trade regions." Along the lines of the LOP we may expect that within a marketing channel margins will not diverge among the stages in the long run.

Testing the LOP by cointegration techniques (Engle and Granger[5], Johansen[6]) has become popular in recent years (e.g. Goodwin[4], Ardeni[7], Baffes[8], Lutz et al.[9], Karbuz and Jumah[10], Silvapulle and Jayasuriya[11]). In addition to testing for price integration, cointegration analysis can also be used to test whether one market can be considered as the central market which drives the prices of the other markets (e.g. Silvapulle and Jayasuriya[11], Ericsson[12], Johansen[13]). The hypothesis of a central market also seems of interest for a marketing channel when testing for the existence of a channel leader structure (Meulenberg and Kool[2]). However, there is one important difference between a marketing channel and a set of spatially dispersed markets that does not allow for the application of cointegration analysis to determine whether one or more stages are leaders. The difference being that if some markets are not functioning well, then this should not necessarily affect the performance of the other markets. In contrast, if the profitability of a marketing channel stage leaves much to be desired, then the continuation of production in the other stages of the marketing channel will be in danger as well. Therefore, within a marketing channel, the margins of all stages, and hence, two successive stages, do not diverge in the long run because of the mechanism by which, through time, the margin of a stage does not only follow the margins of the previous stage and successive stage, but is also followed by the margins of these stages. A stage whose margin is not driven by the margin of the downstream or upstream adjacent stage is considered to be a bottle-neck, because it gives insufficient attention to performance problems in the other stages of the marketing channel. Notice that this lack of attention is not in line with e.g. a chain marketing strategy (Meulenberg and Kool[2]) which is an important instrument in becoming market-oriented or customer-oriented.

In the next section we formalize our framework by means of an error-correction model.

3. Model

Let $M_t = (m_{1t},\ldots,m_{pt})'$ be a vector of margins, where m_{it} $(i = 1,\ldots,p)$ is the margin of stage i 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. Starting point of Johansen's cointegration procedure (Johansen and Juselius[14][15], Johansen[6][16]) is a vector autoregressive model that can be rewritten as

$$\Delta M_t = \Pi M_{t-1} + \sum_{i=1}^{k-1}\Gamma_i \Delta M_{t-i} + \mu + \Phi D_t + \varepsilon_t \qquad (1)$$

where $\Delta M_t = M_t - M_{t-1}$, μ are the intercepts, D_t are centered seasonal dummies which sum to zero over a full year, $\varepsilon_1,\ldots,\varepsilon_n$ are $IIN_p(0,\Lambda)$ and $M_{-k+1},\ldots,M_0$ are fixed. Suppose that $\{M_t\}$ is integrated of order one, then the coefficient matrix Π contains information about the long-run relationships between the variables in M. If rank(Π) $= r$ 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 x r matrices α and β: $\Pi = \alpha\beta'$, such that $\beta' M_t$ is stationary in which case (1) is called a vector error-correction model. The columns of β are called the cointegrating vectors.

If the margins do not diverge, i.e. are cointegrated, then $r = p - 1$ and $\beta' M_t$ consists of $p - 1$ linear combinations of m_{it} and $m_{i+1,t}$ ($i = 1, \ldots, p-1$), cointegrating vector i, say. Given that margins do not diverge, three situations can be distinguished. First, if cointegrating vector i does not enter the Δm_{it} equation in (1) but enters the $\Delta m_{i+1,t}$ equation in (1), then stage i is said to be a bottle-neck. Second, if cointegrating vector i enters the Δm_{it} equation but not the $\Delta m_{i+1,t}$ equation, then stage $i+1$ is considered to be the bottle-neck. Third, if cointegrating vector i enters both equations, then none of the stages is a bottle-neck. Notice that one may consider the absence of cointegrating vector i in both equations as the fourth possible situation. However, in that situation there is no error-correction at all and hence, m_{it} and $m_{i+1,t}$ cannot be cointegrated which does not comply with our assumption that margins do not diverge.

In the next section an empirical application of the procedure outlined in this section is presented.

3. Application

We consider the pork marketing channel in the Netherlands. Three stages are distinguished ($p = 3$): the breeders (stage 1) who produce piglets, the feeders (stage 2) who produce pigs for slaughter and the retailers (stage 3) who sell pork to the consumer. We apply the Johansen procedure to test whether the margins in this channel are cointegrated, i.e. do not diverge in the long run, and to determine which stages are bottle-necks.

An absolute measure of the margins cannot easily be obtained due to a lack of data concerning the costs. By way of approximation, we simply include a trend term in the cointegrating space in (1) to capture the changes through time in the cost per unit output and replace the m_i variables by the output prices. Our sample consists of monthly data and runs from January 1989 up to and including May 1994. The data and their sources are available from the authors upon request.

First, we determine the number of cointegrating vectors using the *trace* and λ_{max} test of the Johansen procedure. The results are displayed in Table 1 and indicate that the null hypothesis of no cointegrating vectors is rejected but the null hypothesis of one cointegrating vector cannot be rejected. As a consequence, according to the Johansen procedure there is only one cointegrating vector instead of $p - 1 = 2$. However, the acceptance of the second cointegrating vector relies on a p-value of approximately 25 percent, which usually would be considered too high. But since the power of the tests are likely to be low for cointegrating vectors with roots close to but outside the unit circle, it seems reasonable in our case to use higher p-values than the usual 5 or 10 percent. Testing the null hypothesis of two cointegrating

Table 1 ***Trace*** **and λ_{max} statistics**[1)]

p-r	*trace*	*trace* 90%	*trace* 95%	λ_{max}	λ_{max} 90%	λ_{max} 95%
1	5.17	10.49	12.25	5.17	10.49	12.25
2	17.47	22.76	25.32	12.29	16.85	18.96
3	58.01	39.06	42.44	40.54	23.11	25.54

[1)] The critical values are taken from Table 2* in Osterwald-Lenum[17]

vectors leads to a p-value of approximately 55% and hence, we tentatively conclude that there are two cointegrating vectors.

The estimated cointegrating vectors are

$$\beta_1{}'M_t = 0.091p_{1t} - 0.050p_{2t} - 0.024T_t \qquad (2)$$

$$\beta_2{}'M_t = 0.031p_{2t} - 2.950p_{3t} - 0.068T_t \qquad (3)$$

where β_j (j = 1,2) is the jth column of β (i.e. jth cointegrating vector), p_i (i = 1,2,3) is the output price per unit of stage i, and T is a linear time trend. Notice that the parameters attached to the price variables in (2) and (3) have opposite signs which is in accordance with non-diverging margins. As an extra check on the stationarity of $\beta_1{}'M_t$ and $\beta_2{}'M_t$ we apply the augmented Dickey-Fuller test (Engle and Granger [5]) and find that in both cases the null hypothesis of non-stationarity must already be rejected at the 1 percent significance level. This result confirms our conclusion that the margins in the pork marketing channel do not diverge in the long run.

Finally, we consider the estimated speed of adjusment parameters α to determine which stage is a bottle-neck. The significant estimates are presented in Table 2. According to the Δp_1 column the margin of the breeders increases (decreases) if the margin of the retailers is

Table 2 Speed of adjustment parameters

error-correction terms	Δp_1	Δp_2	Δp_3
$\beta_1' M_{t-1}$	0	-0.30 (normalized to p_2)	0
$\beta_2' M_{t-1}$	-5.78 (normalized to p_3)	0	-0.75 (normalized to p_3)

lower (higher) than the margin of the feeders than is allowed for by the long-run equilibrium between the margins of the retailers and the feeders. As a consequence, if feeders increase (decrease) their profits relative to the margin of the retailers, then the breeder will also increase (decrease) their margin. The Δp_2 column reveals that if the margin of the feeders is too high (low) relative to the margin of the breeders (according to the long-run equilibrium), then the margin of the feeders will decrease (increase). Finally, the Δp_3 column shows that if the margin of the retailers is too high (low) relative to the margin of the feeders (according to the long-run equilibrium), then the margin of the retailers will decrease (increase).

Given the fact that we selected $k = 1$, so that all lagged ΔM terms in (1) are deleted, we can interpret the results in Table 2 as follows: Because the performance of the retail stage is driven by the profitability of the feeder stage, the retail stage is not a bottle-neck. On the contrary, the margin of the feeders is not driven by the performance of the retailers and hence, according to our definition the feeder stage is a bottle-neck. Nevertheless, the margins in the feeder stage follow the margins achieved by the breeders. This result could be explained by the fact that a considerable number of the farms in the pork channel vertically integrate piglet and slaughter pig production. In 1991, for instance, 30 percent of the piglets were born and fed to slaughter weight at the same farm (Borgstein[18]). Moreover, if we take into account that full vertical control may sometimes be achieved in the absence of vertical integration through adequate contracts specifying "vertical restraints" (Tirole[19]), this percentage might be even higher. On the other hand, vertical integration or full vertical control is rare between the feeder and retail stages.

Finally, the breeder's margin is not driven by the margin of the feeders and thus, the breeder stage is a bottle-neck. Even worse if the retailers perform better (worse) than the feeders for some time, then the breeders, anticipating that the good (bad) results for the retailers will lead to higher (lower) margins for the breeder stage in course of time, plan to increase (decrease) their production to such an excessive extent, that (according to $-5.78\beta_2' M_{t-1}$) the market price of piglets falls (rises) and consequently, (according to $-0.30\beta_1'M_{t-1}$) the market price of slaugther pigs falls (rises) as well, which ultimately (through $-0.75\beta_2'M_{t-1}$) negatively affects the results in the retail sector. So starting with the breeder stage, the breeders and feeders do not react the right way to performance signals from the retail stage. Since we may expect that the retail stage conducts a consumer-oriented strategy, the breeders and feeders have difficulties in adopting this strategy.

4. Conclusions

Our method to trace bottle-neck stages within a marketing channel relies on (possibly interval-scaled) time series data on the profit for a specific marketing channel stage per, representative unit of output. The application of this method to the pork marketing channel is shown to give interpretable results.

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