

## **Transfer-pricing in chains**

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### **1 Introduction**

Chains have a perpetuate interest in the Netherlands. Agricultural chains consist of connected independent units in the agri-food sector whose aim is to realise vertical coordination of behaviour. We argue that common goal-striving behaviour does not necessarily satisfy individual goal-objectives. Transfer-prices can allocate profits in such a way that chain performance is disturbed. Chain-management has to cope with the allocation of profits, otherwise chain-relationships are broken up due to unsatisfied units. In this paper the role of the transfer-price for intermediate products is investigated as a profit-allocation mechanism.

### **2 Change and chain-manifestations**

This coordination of behaviour in chains is induced by the conviction that such coordination leads to better performance on agri-food markets. Coordination of behaviour is seen as one of the possible answers to the necessity for change, brought about by external circumstances (globalisation, environmental laws, liability claims, concentration, diversification on markets etc. (Ramanujam and Varadarajan, 1989; E. van Heck et al, 1989)). Change in external circumstances is expected to go on till far into the 21-st century (Boehlje et al, 1995). From a physical-flow point of view, a chain consists of several entities that are involved in the production and distribution of a product. Restrictions on involvement may be founded on pure juridical grounds (e.g. the EC's goals of free competition (H. Bremmers, 1995), on the organisational (transaction costs) and on the strategic level. Here strategy involves the choice between the different options available to reach a goal. The actual physical flow is a mere manifestation of goal-striving behaviour. In other words: the actual chain is the manifestation of choices made in the past. This chain-manifestation is the starting point for new decisions.

### **3 Individual and common goal-achievement: cooperation and competition**

There are boundaries to goal-achievement, both individual and collective. Individually, for own goals can only be reached within the boundaries of

achieving common goals, when through physical limitations certain options are achievable, and others are not. Mutual dependency **can** limit the pursuit of individual goals. On the other hand, individualistic behaviour can conflict with overall chain-performance.

Chain behaviour is performed with a *specific goal*, usually the improvement of logistics, quality improvement, or the amelioration of information processing.

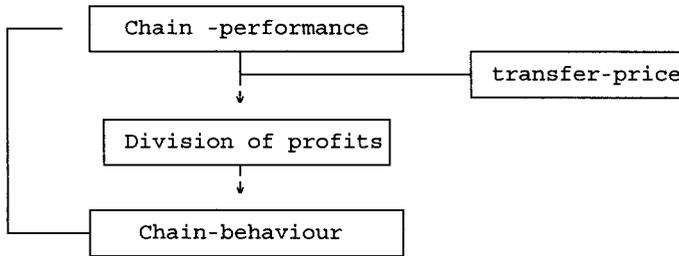
From the striving after specific goals it is expected that:

- the performance of the system in total will be better off;
- the increase in performance will benefit all the parties involved.

As to the first expectation, it should be noted that the expected overall increase in performance does not *have* to occur (M. den Ouden et al, 1992). Units involved in a chain use their own performance-measures, which may conflict with optimal behaviour from a 'chain-standpoint'. The following examples may clarify our standpoint. If a project requires an investment of X, that can be spent by either unit A or unit B, the return on investment (ROI) of the project if carried out in unit A ( $ROI_{pa}$ ) will be less than the overall return on investment of A ( $ROI_a$ ), and if the return on investment attained by B ( $ROI_{pb}$ ) will be higher than  $ROI_b$ , unit B will start the project and A will reject it. If  $ROI_{pa} > ROI_{pb}$ , it would be better from a chain-standpoint that unit A carries out the project. If, for instance, quality improvement is realised to a level where marginal prevention-costs equal marginal costs of faults, this does not necessarily increase chain-profits, since fixed overheads that occur at some stage in the chain or at some unit in the chain, does not influence the short-term optimum. If just-in-time delivery is enhanced at the final stages in the chain, it can mean that at the intermediate product-level larger quantities of goods have to be held in store.

The second expectation is important for perpetuate cooperation and contribution to chain-performance. The expectation is that all units involved will be better off. If there are units in a chain which in their view do not share enough in the advantages of working together, collaboration will be under pressure. We submit that an increase in performance of a chain will not always benefit all parties involved. If, in optimising chain-profits, outputs are set at a level at which marginal chain costs equal marginal returns on the consumer-market, the level of the transfer-price will not necessarily influence the (from a chain-standpoint) optimal production level and market price, since intermediate deliveries are neutral to chain-profit. The intermediate prices are, however, determinant for the division of profits among the stages of the chain. The division of profits influences behaviour in itself and this *induced* behaviour can mitigate total chain-performance (outline 1).

**Outline 1**



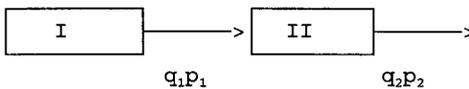
*Interdependency between chain-performance and the transfer-pricing system*

The following examples demonstrate the interdependency between chain-performance and distribution of benefits. Special attention is paid to transfer-pricing problems. Transfer-prices are prices that link pre-final market companies that are involved in producing or processing a product.

**3.1 No capacity constraints, no external market**

If there are no capacity-constraints and no external market exists for an intermediate product, then the transfer-price should be set at a level of marginal costs in the intermediate company at the optimal output-level of the total chain (C. Drury et al, 1992). This transfer-price would result in the intermediate stage not making any profit. It would not survive in a competitive market (total costs are not covered, which is necessary for long-term investments). This is one of the reasons why a cost-plus transfer price is recommended (see C. Tomkins, 1990), or ex-post redistribution-mechanisms are applied (for instance by means of a second transfer-price). Let us consider the situation depicted in outline 2 and suppose that the chain-partners depend solely on each other (that a bilateral monopoly exists).

*Outline 2*



*Closed<sup>1</sup> physical chain, connecting two entities: I and II*

- $q_1$  = quantity transferred from stage I to stage II
- $p_1$  = price for the intermediate product (transfer price)
- $q_2$  = quantity sold at an external market
- $p_2$  = market price of the final product

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1 With the term 'closed chain' we depict the situation in which the firms are mutually dependent.

The profit that company (I) realises can be represented by the following equation:

$$P_1 = qp_1 - v_1(q) - C_1$$

$P_1$  = Profit of stage I  
 $q$  = quantity processed by stage I, II  
 $v_1(q)$  = variable costs, dependent on quantity processed  
 $C_1$  = fixed costs in stage I

If company (I) maximizes profits by adapting its output ( $q$ ), then the following condition should hold for profit-maximization:

$$\frac{\partial P_1}{\partial q} = 0 \wedge \frac{\partial^2 P_1}{\partial q^2} < 0; \text{ so } p_1 = \frac{\partial v_1(q)}{\partial q}$$

The above equality states that the first stage transfers products at a price that equals marginal costs. Profits for company (II) consist of the following components:

$$P_2 = qp_2(q) - qp_1 - v_2(q) - C_2$$

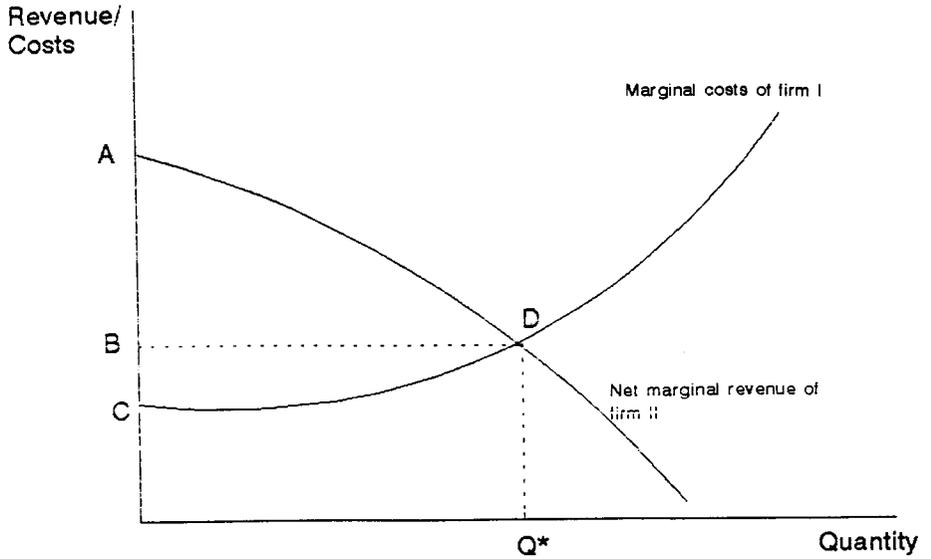
If company (II) wishes to maximize profits, then:

$$\frac{\partial P_2}{\partial q} = 0 \wedge \frac{\partial^2 P_2}{\partial q^2} < 0; \text{ so } \frac{\partial qp_2(q)}{\partial q} = p_1 + v_2$$

$$\frac{\partial qp_2(q)}{\partial q} - v_2 = p_1$$

The equation makes clear that the second company is willing to pay a transfer price that equals 'the marginal value of productivity' of the factor that is supplied by stage I (see: M. Shubik, 1959). The left side of the equation is known as the net marginal revenue (C. Drury, 1992; C. Emmanuel et al, 1994). The optimal output and the transfer price that will emerge can be illustrated in outline 3.

Outline 3



ABD = profit firm II  
 BCD = profit firm I

Emmanuel & Mehafdi (1994), adj.

Suppose that total costs in company (I) equal  $2q^2 + 3q + 5$  and (for reasons of convenience) company (II) has an identical cost-function. The price of the end-product ( $p_2$ ) depends on quantity supplied, for instance as follows:  $p_2 = -4q + 30 \mid 0 \leq q \leq 7,5$ . Then from  $dP_1/dq_1 = p_1 - 4q - 3 = 0$  and  $dP_2/dq = -12q - p_1 + 27 = 0$  it follows that  $q^* = 1,5$  and  $p_1 = 9$  (= marginal costs at the optimal output level). The division of profits is  $P_1^* = -0,5$  and  $P_2^* = 8,5$ . This implicates that no long-term viable situation exists for stage I unless profits are redistributed (for instance by means of a second transfer-price, a dual-pricing system). In the above solution to the distribution of profits, firm (I) would not however survive.

The same optimum as calculated can be derived from common profit-maximisation against the final-product market. Total chain profits are  $P_1 + P_2$  which equal to  $p_2q + p_1q - p_1q - 4q^2 - 6q - 10$ .

$$\frac{d(P_1+P_2)}{dq} = 0; \quad \text{hence } p_2^* = 24 \text{ and } p_1^* = 9; (P_1 + P_2)^* = 8.$$

It is (as to Shubik (1959)) the solution Von-Neumann and Morgenstern would suggest, namely joint collusion against the market (which means playing an *essential* game). However, as to Von Neumann-Morgenstern, common profit should be redistributed with side-payments. In the equivalent Nash-solution, profits are redistributed taking into account the profits firms would make if threat-strategies of non-cooperation were to be adopted. Since a decision to

fight would lead to a loss of 5 for each of the companies, total profits would be split evenly (M. Shubik, 1959). firm (I) would earn a profit of 4. The transfer-price ( $p_1$ ) can be calculated that guarantees this profit:

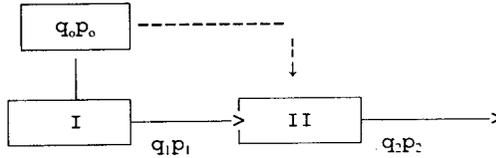
$$P_1 = 4 = p_1 \times 1,5 - 2 \times 1,5^2 - 3 \times 1,5 - 5. \text{ Hence } p_1 = 12.$$

Note that if company (II) were to use this transfer-price as one of the parameters for profit maximization, the goal-function would be:  $P_2 = -6q^2 + 15q - 5$ . Hence  $q^* = 1,25$ ,  $P_2 = 4,375$  and  $P_1 = 3,125$ . Total profits would be 7,5 which is less than the maximum possible, namely 8. Company (I) gains less than company (II) loses, so the viability to threats can lead to a non-zero sum competitive game.

### 3.2 External market

Consider the case in which company (I) has no capacity-constraints and can either sell its intermediate product at a fixed market-price of, for instance 5 ( $= p_0$ ), or process it to company (II). Variable costs per unit of the intermediate product ( $v_1$ ) are supposed to be constant and 2, and variable costs of the end-product-company are constant and 6. The market-price of the end-product is assumed to be constant and 10. We assume further that the intermediate and final product-markets are perfect and competitive.

#### Outline 4



Consider that total output  $q (= q_1 + q_2)$  is (apart from capacity influences) infinite, since the price is higher than variable costs on both markets. Total profits ( $P_1$ ) of company (I) equal:

$$P_1 = q_0 p_0 + q_1 p_1 - v_1(q_0 + q_1) - C_1$$

If there is a perfect market for the intermediate product,  $p_1$  must equal the market price  $p_0$ . If  $p_1 < p_0$ , no transfer to company (II) takes place, as company (I) is better off in selling the intermediate product externally than by transferring it to company (II)<sup>2</sup>. Company (II) could buy the necessary products from that same market at a market-price of 5. If  $p_1 > p_0$ , firm (II) would instantly be better off if the intermediate product is bought from outside the chain. Considering that in a situation of decreasing returns output of (I) would

2 It should be noted that asset specificity (or its cost-accounting counter-part: switching-costs) can limit flexibility.

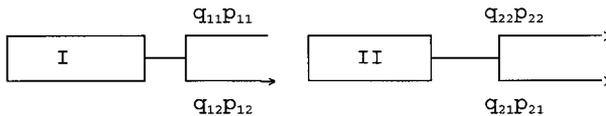
be increased up to the point where  $d(v(q)/dq$  equals  $p_0$ , the transfer-price would equal marginal costs per unit, which is the market-price of the intermediate product in a competitive market.

### 3.3 Capacity-constraints

If there are one or more capacity-constraints (bottle-necks), individual performance maximization can work contraproductively for the performance of the total chain.

In the case of capacity-constraints, an optimum can be found and transfer-prices can be set by means of linear-programming techniques (C. Drury, 1992). The determined transfer-price is constitutive for the redistribution of advantages that are derived from the commonly accepted performance goal(s). Consider the chain-manifestation in outline 5 as an example of the depicted situation.

#### Outline 5



Company (I) produces two intermediate products,  $q_{11}$  and  $q_{12}$ , under the limiting circumstances that  $q_{11} \leq 4.000$  and  $q_{12} \leq 5.000$ . The necessary inputs for the output in firm II are:

	$q_{21}$	$q_{22}$
$q_{11}$	2	1
$q_{12}$	0,5	1

Variable costs per unit of  $q_{11}$  and  $q_{12}$  are supposed to amount to 3 and 4 respectively. Suppose the sales restrictions for end-products  $q_{21}$  and  $q_{22}$  are 6.000 and 3.000 units respectively, at fixed selling-prices of 10 and 12. The solution that would lead to maximum profits for the total chain would be the production and selling of 3.000 units of  $q_{22}$  and 500 units of  $q_{21}$ , leading to total profits of 16.000. The transfer-price for  $q_{11}$  is 4 (= variable costs of 3 + shadow price of 1) and for  $q_{12}$  equals variable costs, as  $q_{12}$  does not limit optimal output. So no stimulus for company (I) exists for producing  $q_{12}$ , which leads to chain-suboptimality<sup>3</sup>. Performance-goals and transfer-prices have to be dictated under these circumstances, which is not really possible in a chain.

3 Similarly there is no stimulus for company (II) to produce  $q_{21}$ , as this product does not have a shadow price; see C. Drury, 1992: 770.

## 4 Conclusions

The conclusion must be drawn that there is a strong linkage between the economic situation in which a chain develops and its influence on the allocation of profits over the involved units. This in turn can be seen as a chain-management problem. In our view chain-management has to be focused on reaching mutual agreement, if the goals of independent units and of the chain in total diverge. To formulate such an agreement, criteria are necessary for measuring total chain-performance and the contribution of individual parties to total chain-performance. These criteria have yet to be developed, and it is questionable whether the market-mechanism can provide enough incentives for long-term chain-involvement. In the auction system for vegetables, fruit and flowers for instance, transfer-prices are determined by market-price mechanisms. This only leads to an optimal chain-result where there is a perfect external market. Perfect market conditions do not exist nowadays: in many cases information assymetry occurs (O.E. Williamson 1975, 1985).

Some authors (e.g. Van Dalen, 1994) proclaim chain-leadership as a possible solution for diverging goals among parties within a chain. Chain-leadership however requires legitimation: criteria have to be developed that focus all efforts in the same direction; criteria are needed too if redistribution of surpluses has to take place. Without such criteria, chain-leadership means no more than an exhibition of power: financial power means that the strongest partner will collect all the benefits (under the present circumstances this is the retailer, for sales on consumer markets usually limit activities).

## 5 Future research

In the preceding discussion we have seen two different, but intertwined, problems: chain optimization and the division of the surplus that is rendered by common effort. What does this mean for future research?

- first, the manifestation of chains in reality can be analysed by using management-accounting techniques, using short and long-term costs and profits as variables.
- second, bargaining between parties involves game theory, whereby the parameters of the game are set, among others, by cost factors and factors influencing the *redistribution of profits*. Introduction of selling costs, costs of coordination and transaction complicates the pictures presented, but does not alter the presented models significantly.
- third, a definition of 'chain' in abstracto is useless, as 'chain' is an *ex-post concept*: It merely depicts actual or realized physical flows. *Chain-strategy* is the *ex-ante* concept, and the chain is the realisation of imputed strategy. The chain-realisation is the starting point for future decisions. The possibility of simulations of chain manifestations from an economic perspective should be further investigated.

- fourth, the significance for chain-manifestations of topics like quality, environmental risk etc., can be analysed by transforming these risks in terms of costs and revenues and their distribution.
- fifth, chains will have a certain stability if the individual advantage that is gathered from working together surpasses the benefits of alternative capacity application. The benefits that flow to a separate entity depend on total chain-performance *and* the share of total gains that it can secure for itself.

To make statements on chain-performance and the division of gains, modelling is of primary importance. The development of models that can explain behaviour in and of chains is still in its initial stages, especially if one looks at *financial performance* as a determinant for behaviour. There is a great deal of work to be done in the near future.

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