THE STEADY STATE PRICE ANALYSIS OF TWO STAGE SUPPLY CHAIN

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***Abstract**: This paper is given over to steady state price analysis of two stage supply chain with homogeneous products. It is assumed with one producer at the beginning of supply chain and one end customer characterized with aggregated demand at the end of supply chain. As intermediate nodes of supply chain, two vendors supplying product from producer to consumer are considered. The aim of suppliers, unlike in classical approaches that maximizing profit, is to maintain market share in the segment sales of the product. The analysis is based on equilibrium between linear supply and demand functions at both sides of the supply chain. The result is the evaluation of the equilibrium strategy of subjects at both sides of the supply chain and analyses how different actors have to adapt their pricing strategy.*

***Keywords:** supply chain, steady state price, microeconomic analysis.*

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1. INTRODUCTION

In recent years supply chain management has focused its attention on managing decentralized entities operational decisions, that have an impact on supply chain profit and thus to all other actors in the supply chain.

Classical analysis of supply chain effectiveness are focused on examining the situation where the supply chain gain diversifies among its entities and at least one has a relevant impact on the demand for goods (Fiala, 2002). More recent trends are focused on the utilization of natural tool in maximizing entities own utility market function with the regard to the behavior of other market actors - the game theory [1], [4]. Microeconomic analysis based on steady states of supply or demand functions can be effectively used too [2].

Nowadays, attention on creation of supply network structures has increased and natural requirement is its optimization. Network structures are formed by separate entities of supply chain, among which mutual cooperative ties exist. Its optimization is result of an effort to maximize the efficiency of the entire supply chain, thus optimization of supply chain management from producers via distributors to the final customers. Maximum efficiency can be achieved only in conditions of mutual cooperation among various actors in the supply chain and the optimization of material and information flows, as well as the willingness of subjects to participate in the global supply chain optimization (so-called cooperative decision-making) [3], [5], [6].

With increasing number of supply chain entities different network structures can be achieved. In supply chain structures two types of interactions are distinguished one-to-one and many-to-one. According to interaction type serial, parallel and combined supply chain can be considered. Figure 1 ilustrates structures of serial, parallel and combined supply chain in order from the top to the bottom.

According to number of interactions at various levels of supply chain one or multiple stage supply chain is distinguished.

2. TWO STAGE SUPPLY CHAIN

Let suppose that in the supply chain, there is an intermediary, for example in a real situation the manufacturer does not sell its product directly to final consumers, but sell it through wholesale warehouses or chain stores, etc. In this case, we simply assume that the beginning of the supply chain is represented by the manufacturer of the product, end of the chain is represented by end customer characterized by aggregated demand for a

product that passes between two intermediaries in the supply chain, which consists of two entities (intermediate warehouses). Let denote producer by the letter P, end customer by the letter C and intermediaries by letters S_1 and S_2.

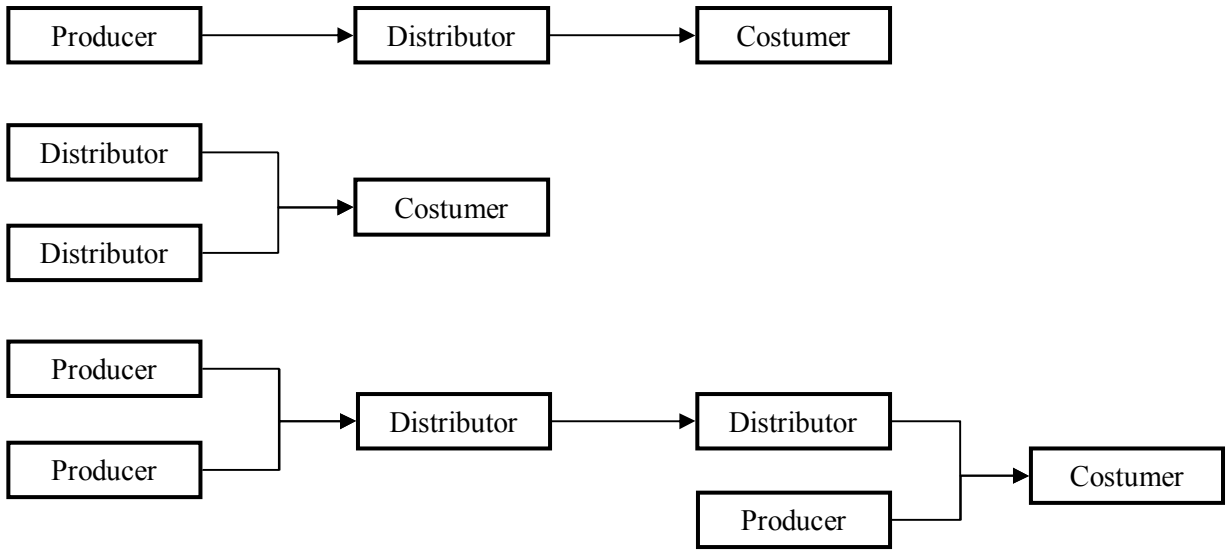

Figure 1. Serial, parallel and combined supply chain

Beside the classical objective of individual actors in the supply chain that is the profit maximization (from customer point of view cost minimization of purchased goods), other objectives can be set. In further analysis we will consider objective to obtain or maintain market share in given product segment sales under consideration, product passes through multiple stage supply chain. From above stated assumptions, we will analyse supply function on the first stage of supply chain (between producer and intermediaries) and demand functions at second stage of supply chain (between intermediaries and end customers), in order to generate price equilibrium at various stages of the supply chain. By evaluation of the equilibrium strategy, it can be analysed which entity of supply chain and how it should adapt its strategy. For simplicity, we will consider the linear form of supply and demand functions for each of supply chain actor.

Considered case can be represented by graphic model depicted on the Figure 2.

Let assume that, producer P supply quantity depends on the selling price and it can be expressed as a linear supply function:

$$s_p\left(p_p\right) = c_p + d_p p_p$$

where

c_p denotes the smallest value of producer P supply,

d_p denotes marginal increase of producer P supply

p_p denotes the unit price of the product in the first stage of the supply chain.

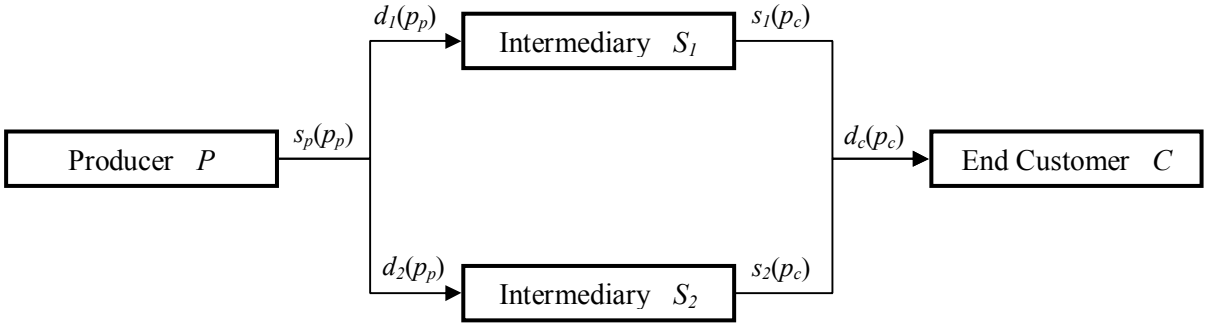

Figure 2. Two stage supply chain

Let assume that, on second stage of supply chain two intermediaries S_1 and S_2 operate (duopoly market structure), whose linear demand functions on considered product depend on the price from the first stage and it can be stated as:

- For the first intermediary S_1:

$$d_1(p_p) = a_1 - b_1 p_p$$

where
a_1 denotes saturation level of demand of the first intermediary S_1,
b_1 denotes marginal decrease of first intermediary S_1 demand,
p_p denotes the unit price of the product in the first stage of the supply chain.

- For the second intermediary S_2:

$$d_2(p_p) = a_2 - b_2 p_p$$

where
a_2 denotes saturation level of demand of the second intermediary S_2,
b_2 denotes marginal decrease of second intermediary S_2 demand,
p_p denotes the unit price of the product in the first stage of the supply chain.

On the second stage of supply chain it can be assumed, that considered intermediaries S_1 and S_2, implement supplier relationship with the last level of supply chain and supply for end consumer is represented by linear supply functions:

- For the first intermediary S_1:

$$s_1(p_c) = c_1 + d_1 p_c$$

where
c_1 denotes the smallest value of first intermediary S_1 supply,
d1 denotes marginal increase of first intermediary S_1 supply,
p_c denotes the unit price of the product in the second stage of the supply chain.

- For the second intermediary S_2:

$$s_2(p_c) = c_2 + c_2 p_c$$

where
c_2 denotes the smallest value of second intermediary S_2 supply,
d_2 denotes marginal increase of second intermediary S_2 supply,
p_c denotes the unit price of the product in the second stage of the supply chain.

On the second stage of supply production is delivered to the end customer characterized by aggregated demand which linear function can be stated as:

$$d_c(p_c) = a_c - b_c p_c$$

where
a_c denotes saturation level of demand of end customer C,
b_c denotes marginal decrease of end customer demand C,
p_c denotes the unit price of the product in the second stage of the supply chain.

Based on above assumed assumptions price steady state can be found for each stage of supply chain:

- steady state price strategy among producer P and intermediaries S_1 and S_2 assuming the same purchasing price p_c for both intermediaries, can be calculated based on relations:

$$\begin{aligned} &(a_1 - b_1 p_p) + (a_2 - b_2 p_p) = c_p + d_p p_p \\ &\frac{a_1 + a_2 - c_p}{b_1 + b_2 + d_p} = p_p \end{aligned} \quad (1)$$

  Steady state price p_p for the first stage of supply chain is increasing with increase of demand saturation level of both entities ($a1$ and a_2) and decrease of parameter for smallest supply value c_p, coefficient of supply growth d_p and marginal demand decrease of intermediaries (b_1 and b_2). In case of opposite values of stated coefficients, the steady state price for the first stage of supply chain is decreasing.

- Steady state price strategy among intermediaries *S1* and *S2* and end customers C assuming the same purchasing price p_c for both intermediaries, can be calculated based on the relationship:

$$\begin{aligned} &(c_1 + d_1 p_c) + (c_2 + d_2 p_c) = a_c - b_c p_c \\ &\frac{-c_1 - c_2 + a_c}{d_1 + d_2 + b_c} = p_c \end{aligned} \quad (2)$$

  Steady state price p_c for the second stage of supply chain is increasing with increase of

demand saturation level of end customer a_c and decrease of parameter for smallest supply value of both intermediaries (c_1 and c_2), both intermediaries marginal increase of supply (d_1 and d_2) a marginal decrease of end customer demand b_c. In case of opposite values of stated coefficients, the steady state price for the second stage of supply chain is decreasing.

3. CONCLUSION

Based on the considerations stated, price p_p and p_c can be analyzed, if $p_p < p_c$ is true. Difference $p_c - p_p$ represents supply chain intermediary margin. The situation, however, occurs when the same amount of trade conducted on the first and the second stage of the supply chain under consideration is realized. In case of smaller value of supply realized at the first stage of the supply chain, entities which represent an intermediary in the supply chain decide whether to increase the demand for goods from the producer, which can be achieved by increasing the price that is paid for the product. The same effect can be achieved by increasing the end customer price, resulting in a reduction of demand for the product.

In case of greater value of supply realized at the first stage of the supply chain entities which represent an intermediary in the supply chain, must deal with this situation in the opposite way.

Price strategy selection in the supply chain is determined by a number of indicators, because, as mentioned above, entities that act as intermediary bodies in the supply chain, in addition to profit maximization have objective to maintain market position. Accordingly it is appropriate to make a further analysis, for example analysis based on game theory, which provides the appropriate tools to deal with this kind of problem, ie determine which method of settlement of steady state pricing strategy in the first and second stages to use.

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