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PROFIT MARGIN IN SUPPLY CHAIN MODEL

Abstract

This contribution clarifies basic principles of profit margin in supply chain theory, defines the term supply chain, deals with the issue of double margin and determines quantitative characteristics of serial, parallel and mixed supply chain model of multiply margin.

Within the term supply chain we understand a multi-level system encompassing all the elements (members) involved in order to fulfil the demands of final customer. A conventional supply chain consists of 5 basic levels (units) where material, financial, informational and decision-making flows are carried out:

1. suppliers
2. producers
3. distributors
4. sellers
5. customers

Each unit prefers its own interests while not able to optimize functioning of the chain on its own. We mostly encounter the supply chain with a linear structure as given in Figure 1 and such a structure involves 5 basic levels.

Figure 1. Linear supply chain

In practice, we may come to do with such a linear supply chain where some levels do not exist or are demonstrated by other forms.

When supply chain makes profits dividing that between two or more members while at least one of them is having a major impact on a demand then we speak about double profit margin. Each member of the supply chain considers only its own profits and profits generated at the level of the chain as a whole is then irrelevant.

Profit margin is given by the formula:

\[
\text{Profit Margin} = \frac{\text{Net Profit}}{\text{Total Sales}} \cdot 100 \% \tag{1}
\]
Double profit margin

The principles of double profit margin model are based upon the following prerequisites:
- supply chain is made up of two units: supplier and buyer (Figure 2)
- flows are carried out between these units
- costs of production unit at the level of the supplier equal c and unit price for production reaches the level w
- buyer ask supplier for volume q and then sells for price p(q)
- price p(q) is demonstrated by decreasing, concave and double differentiable inverse function toward demand function

Figure 2. Two-tier supply chain system (double profit margin)

If subject (or coordinator) exists in supply chain, which dispose of full information and control the supply chain for maximizing profits then we speak of centralised handling $q^0$ (the first preferable handling):

$$z(q) = q \cdot [p(q) - c]$$

If no subjects exist in supply chain disposing of full information and striving for maximizing profits then we speak of decentralised handling $q^*$:

$$z_1(q) = q \cdot (w - c)$$

$$z_2(q) = q \cdot [p(q) - w]$$

where:
- $z_1(q)$ - supplier profits
- $z_2(q)$ - buyer profits

If centralised and decentralised handlings are different ($q^0 \neq q^*$) then is possible to study how to modify the behaviour of individual members of the chain so as to new decentralised handling would correspond with the centralised handling. In this case, buyer orders less volume as optimal volume is with regard to the chain as a whole ($q^0 > q^*$) where supplier makes positive profits due to the maturity:

$$z(q^0) > z_1(q^*) + z_2(q^*)$$

More effective decentralised handling is more closer is to the results of centralised handling. If pursuing profits then for efficiency e the following applies:

$$e = \frac{z_D}{z_C} = \frac{z_1(q^*) + z_2(q^*)}{z(q^0)}$$
Setting a price that is equal to marginal costs is seen as one of the solutions to deal with the double profit margin but supplier profits is zero in this case. Though sharing profits within the members seems to be more sufficient option where supplier profits makes \( z(q) \) and for buyer profits applies \((1 - v) \cdot z(q)\), where \( v \in <0,1> \). The supply chain thus makes maximum profits and price \( w \) is irrelevant for the members of the supply chain.

General double margin outcomes apply also in conditions of multiply margin in the chain structures. Constant processing of unit costs within individual supply chain segments \( c \) is a prerequisite and also the availability of supply chain final production in demand where the chain is specific in nature and of a linear waveform in the shape:

\[ q(q) = a - b \cdot p \]  

where:
\[
\begin{align*}
a, b & \quad \text{positive real numbers} \\
p & \quad \text{price of final production determined by chain output segment}
\end{align*}
\]

We recognize 3 basic types of supply chains with multiply margin, namely: serial, parallel and mixed chains. When it comes to decentralised supply chain of any kind the efficiency plummets given the growing number of segments. If there is a chain of the same number of segments, serial supply chain efficiency is lower than efficiency of parallel supply chain. Efficiency values of supply chains of both parallel and serial structure indicate efficiency thresholds for supply chain of mixed structure.

**Serial supply chains**

With a regard to a serial supply chain we find its segments ordered linearly with one linkage to the next/subsequent segment (Figure 3).

![Figure 3. Serial supply chain](image)
\[ z_i = \frac{b}{2^{n+1}} \left[ \frac{a}{b} - \sum_{j=1}^{n} c_i \right]^2 \quad i = 1, 2, \ldots, n \] (10)

4. decentralised serial supply chain efficiency:

\[ e = \frac{z_{D}}{z_{C}} = \frac{2^n - 1}{2^{2n-2}} \] (11)

Parallel supply chains

A parallel supply chain is made up of n-1 segments ordered in parallel with a linkage to one subsequent segment (Figure 4).

For parallel supply chain the following applies:
1. centralised parallel supply chain profits:

\[ z_C = \frac{b}{4} \left[ \frac{a}{b} - \sum_{i=1}^{n} c_i \right]^2 \] (12)

2. decentralised parallel supply chain profits:

\[ z_D = \frac{2n-1}{n^2} \cdot \frac{b}{4} \left[ \frac{a}{b} - \sum_{i=1}^{n} c_i \right]^2 \] (13)

3. decentralised parallel supply chain last member profits:

\[ \pi_n = \frac{b}{4n^2} \left[ \frac{a}{b} - \sum_{j=1}^{n} c_j \right]^2 \] (14)

4. decentralised parallel supply chain other segments profits:
\[ \pi_i = \frac{b}{2n^2} \left[ \frac{a}{b} - \sum_{j=1}^{n} c_j \right]^2 \quad i = 1, 2, \ldots, n - 1 \]  

(15)

5. decentralised parallel supply chain efficiency:

\[ e = \frac{z_D}{z_C} = \frac{2n-1}{n^2} \]  

(16)

Mixed supply chains

Here we refer to the combination of both above mentioned types – serial and parallel supply chains. In such case new levels are formed within the chain. When speaking about a level we mean a set of all segments output of which have to pass through the same number of other segments until reach final consumer. Each segment of the supply chain is represented by two number figures. The first number (m) indicates the supply chain level and the second one refers to a serial number of the segment at a given level – vector \( n = (n_1, n_2, \ldots, n_m) \). I-th part \( n_i \) denotes the number of segments at i-th level of the chain. The final segment remains alone at its level (Figure 5).

![Figure 5. Mixed supply chain - vector \( n = (3, 3, 2, 1) \)](image_url)

For mixed supply chain the following applies:

1. centralised mixed supply chain profits:

\[ z_C = \frac{b}{4} \left[ \frac{a}{b} - \sum_{i=1}^{m} \sum_{j=1}^{n_i} c_{ij} \right]^2 \]  

(17)

2. decentralised mixed supply chain profits:

\[ z_D = \frac{2}{\prod_{i=1}^{m} n_i + 1} \left[ \frac{a}{b} - \sum_{i=1}^{m} \sum_{j=1}^{n_i} c_{ij} \right]^2 \]  

(18)

3. decentralised mixed supply chain ij member profits:
4. decentralised mixed supply chain efficiency:

\[ e = \frac{2 \cdot \prod_{i=1}^{m} n_i + 1 - 1}{\prod_{i=1}^{m} n_i + 1^2} \]

Supply chain management measures efficiency itself and apart from that also involves other associated operations relating to designing (or drafting), respective control or improving the overall efficiency. The measurement is usually focused on the whole supply chain not only on its particular segments. Nowadays supply chains shall be distinguished by more complex structures and driving force and hence supply chain management is referred to as a significant element and a way of making the value for customer.

Supply chain units (elements) are often independent and have their own interests and provided that any such unit may not optimize the supply chain on its own but rather each unit shall optimize its own rules since assume the other units to act in similar way. Such behaviour does not allow optimizing the whole supply chain.

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