Impact of disequilibrium price on sales volume in a logistics system

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Abstract. The question of the influence of the price set by the producer on the sales volumes in a logistics system with a linear structure is considered. The impact of price on sales volumes is considered from the perspective of removing the information uncertainty that occurs when analysing the balance between supply and demand of a probabilistic nature. The impact factor analysis is based on the total cost pricing method, which includes production costs and profits. The latter is determined on the basis of a mark-up factor calculation. Besides, the offered price, including the mark-up, is considered a constant over the allotted time interval, and its value must be in the seller's and buyer's area of interest. This approach has advantages over traditional pricing methods and is consistent with the Erow-Debre stability-oriented pricing model. A description of the process of changing the mark-up rate within outlined limits, in which it varies according to the proposed sales volume, is presented. The price and sales volume limits are justified based on the possibility of using a «cognitive» approach. The demand functions for products and rate prices in the area of their possible «overlapping» when buying/selling in micro-markets are considered.

1 Introduction

The logistics system, in the structure of the economic system, occupies a leading position and its task is to manage the material flows. Logistics as a flow distribution system determines the balance between the processes of production and consumption of goods. Here, the role of price and sales volumes, and their interrelationship in setting and determination, can be regarded as an important reference for balancing system issues. Solving the issues of price and volume balancing in the distribution of material flows in distribution trade and intermediary networks is a complex task that requires formalization and solution algorithm.

There are a number of papers dealing with distributional aspects of commodity flows in logistics systems [1] and with price and volume issues in commodity promotion [2].

The problem and the relationship between price and volume will be further discussed in relation logistics systems with a linear structure. It depicts the sequential connection of elements (network agents), starting from the producer to the final consumer of the goods. As

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for agent characteristics, they can be found in [3]. These structures are called "logistics channels" with direct or horizontal links, where the distribution of material resources and those in stock is carried out at the same hierarchical level. This representation of the logistics structure can be considered as the simplest and easiest way to distribute the flow of goods between agents. However, the question remains how to find answers regarding the relationship between prices and promotion volumes in the network's micro-markets and agents' stocks.

2 Materials and methods

The interaction of agents in micro-markets is a factor in managing price and consequently the volume of buying/selling a commodity. To implement it, agents rely on the tools, data and knowledge at their disposal. Among the available data, the needed statistics should be highlighted to perform a system analysis. There is insufficient information in this implementation, which indicates uncertainty. Therefore, the agent does not have sufficient knowledge that he could have obtained from his own perspective. The presence of a significant amount of information uncertainty in the analysis and subsequent management of decision-making process will lead to unreasonable costs associated with keeping inventories in stock.

In the process of information collection, processing, analysis and making decisions, managers, based on the past, use data on prices and sales volumes of purchase/sales of their products. The focus is on questions of equilibrium between supply and demand, which can be answered in general terms using the "Marshall Cross" (a graphical representation of the intersection of supply and demand trade with respect to the price factor in a market interaction situation). In fact, the manager is trying to decide on price and volume at the same time, which essentially complicates the search for equilibrium points. Although the construction of supply and demand curves can answer question, there is no guarantee that, under a number of factors, the supply and demand functions will meet the changed conditions. In order to eliminate such difficulties, i.e. to remove uncertainty of information, it is advisable to take the price influence factor as a basis for determining the sales/purchase volumes. Thus, the price will not be involved when considering the balance between supply and demand.

Looking at the prerequisites for solving the problem, the price is determined by the producer and the network intermediary [4]. by the methods at their disposal. The main one among them is the total-cost (cost + profit) pricing method [5]. It defines the price of a product as the unit cost of the product multiplied by a mark-up factor (1+m), where m is the mark-up rate. Having determined the price using this method, we will assume that there are no agents in the network claiming to change the price. In reality, the seller can change the rate m in the event of changing market fluctuations. This approach to price determination does not contradict the Arrow-Debre model [6], which focuses on price stability. The value of the price can be assumed to be unchanged if the conditions are met:

- Sufficient labour and material stocks for the production and sale of products.
- Production methods (technology) remain unchanged.
- The mark-up rate m remains constant.

Thus, the underlying assumptions for determining prices, according to [5], can be seen as follows:

- The lack of correlation between prices and quantities when determining them.
- The theory of price determination does not exclude from the analysis of the theory of value the development of production technologies.
- A quantity-adjustment process is provided for.

Pricing techniques are well known, and prices are determined according to the "cost plus mark-up" principle: where m is the mark-up rate, c is the unit cost of production. This approach to pricing has advantages over the traditional methods mentioned above:

- Actual prices that are applicable in the micro-markets of the network are simply determined. This frees up the double system of accounting for natural and market prices.
- There is no need to change prices before any of the significant factors that have a low probability of occurring arise.
- The price will change if the producer or intermediary does not switch to new production and marketing technologies.

3 Results

Taking into account the two indicators of micro-market functioning, it is evident that the role of other factors is not taken into account. Each of these affects volume formation patterns, so the task of assessing the price-volume relationship leads us to be satisfied with modelling, taking into account the probabilistic nature of the processes.

Under the condition of our problem, the price is defined a priori and fixed over a long period of time. Only the mark-up rate m will be subject to change, the value of which is limited between 0 and $m_{\max}$, where $m_{\max}$ is determined on the basis of the micro-market situation. The relationship between price and volume can be represented on the points field (Figure 1) with the coordinates $\left(P(m);Q\right)$, where $P(m)$ is the price including the mark-up, Q is the volume of purchase/sale.

The Figure conventionally singles out the purchase/sale area (point with coordinates $\left(P(m);Q\right)$), when market conjuncture meets the buyer's demands, confirmed by purchasing power. The buyer's demands can be represented as a simple function: $Q = D/P$, where D is the money allocated to purchase the product.

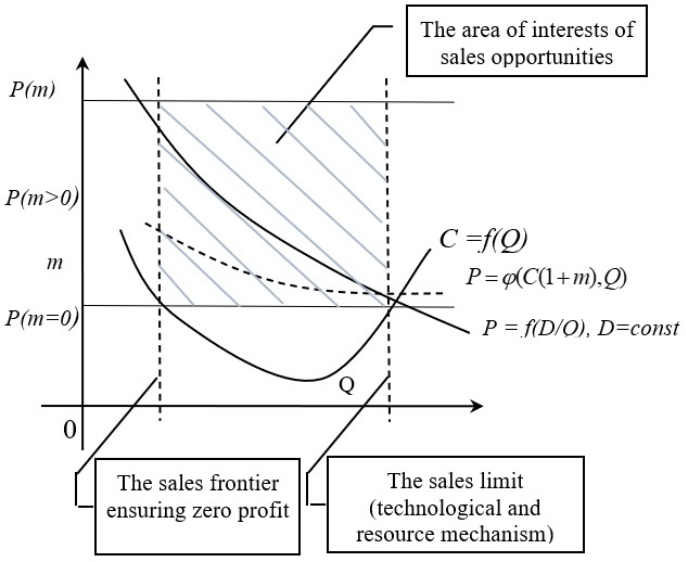

Fig. 1. Area of «overlapping» of buying/selling in micro-markets.

In Figure 1, the area of interest is marked conventionally, excluding the boundaries formed by the cost functions $C = f(Q)$ at the bottom and the rate $m = \psi(Q)$ at the top. The area on the left and right is bounded by the Q values. Possible effective solutions that are primarily in the interest of the seller will lie in this area. If we consider the buyer's ability to purchase the product, the function $P = f(D/Q)$ must pass through the area of interest (see Figure 1). The form of this function can vary and can be constructed, for example, from the application of the cognitive approach in estimating price-volume influencing factors [7]. By constructing the function $P = \varphi(C(1+m), Q)$ and $P = f(D/Q)$ and solving them, it is possible to determine the finding of the "equilibrium point" in the area of interest of the seller and the buyer.

The coordinate point thus obtained will $(P;Q)$ determine the value Q at a given value P on the seller's side.

However, the "equilibrium point" may not be in the equilibrium area. This is possible, for example, when the function $P = f(D/Q)$ is in its simplest form, without taking into account the uncertainties in the information needed to predict the quantity to be purchased at the prices offered.

4 Discussion

The seller in a micro market is able to adjust the rate m between *m*=0 and *m*=max. The rate m cannot be considered constant not only in magnitude but also in time, as there are many factors involved. Let us briefly consider one approach in their estimation, called 'cognitive'. We then briefly present its possibilities in determining the rate m. The paper [7] discusses the role of cognitive science in the processing of price and sales volume data in micro-markets.

When considering the growth/decline of Q as some organised set, the following is often pointed out:

- Growth is multiplicative if the structure of this set does not change.
- Growth is additive if the structure is subject to restructuring.

Additive growth is associated with a radical change in the structure of the object. It is due to the technological transformation at the producer of a marketable product. In this case, the cost of production and, consequently, the price changes drastically, and the product itself undergoes a qualitative change.

When considering an increase in the rate $m \geq 0$, its value is primarily oriented to the quantity of goods sold and does not exclude the probabilistic nature of events. Such events would include the purchase/sale a quantity of a commodity at a known price.

The additive process involves summing up the unit $m \geq 0$ values for each of the events *i* under consideration. In this case, the probability equation for event *i* will be of the form:

$$P_i = \frac{1}{k} \tag{1}$$

where *k* is the set of units.

Suppose that *k*=1 is some unchanging value of rate *m,* determined by the value:

$$k = \frac{\left(m_{\max} - m_{\min}\right)}{\left(m_i - m_{i-1}\right)},\ \forall\left(m_i - m_{i-1}\right) = const\,. \tag{2}$$

Here $m_{\max}$ and $m_{\min}$ - respectively, the maximum and minimum possible rates justified by the seller. By extending the range of $\left(m_{\max} - m_{\min}\right), k \to \infty$. Hence, according to (1),

$P_i \to 0$. In practice this will mean: by increasing linearly the number of units k (i.e. the value of m), the probability of buying/selling the commodity will decrease. If we apply (1) to the sales volume, then as the unit sales volume increases, the probability of selling/buying more goods will decrease.

However, there is an equally important circumstance here, which has to do with the demand for the product being sold. The buyer has no interest in the fact that with the purchase of more goods, the price (or m) will increase. Under such circumstances, there is a trade-off whereby on the one hand rate m has to satisfy the requirement to generate the planned sales revenue, and on the other hand to purchase such a quantity of goods at $P_0(1+m)$, that would satisfy his needs. The search for a compromise solution is possible over the whole interval in which rate m is determined. Here it becomes obvious to relate the additive process of purchased volume to the additive process of the price, given the rate, $P = P_0(1+m)$. Matching $P = \varphi(C(1+m), Q)$ with $P = \varphi(D/Q)$, the change in m will not relate to an additive growth process, whereas the sales price may correspond to it.

Next, consider the multiplicative process involved in determining the probability that event i will occur.

$$P_i = m_i\left(\sum_{i=1}^{k} m_i\right)^{-1}, \ \sum_{i=1}^{k} P_i = 1. \tag{3}$$

Expression (3) indicates an increase in the probability of occurrence of events *i* within $0 \le P_i \le 1$. The greater the value m_i, the more likely it is that an event will occur from the whole spectrum m_i. However, this growth has to be associated with the demand for the product. In order to satisfy it, the price of demand $P = \varphi(D/Q)$ and the price of supply $P = P_0(1+m) = \varphi(Q)$ must coincide. In this case, the value of m will be defined as the difference between these functions, and its growth will be multiplicative.

5 Conclusion

Considering the possibility of determining the rate to cost price of a product, a cognitive approach can be considered as one way of doing this. Relying on the availability of statistical data on the state of the process of buying/selling goods, the hypothesis of considering it as a system becomes obvious. Considering it as an organised set, it is appropriate to note the process of growth, primarily in the price itself and in sales volumes. By considering two stochastic growth mechanisms: additive and multiplicative, it is shown that additive growth in both price and purchase/sale volumes will have an equal probability of growth, indicating a structural adjustment in the system.

In turn, stochastic multiplicative growth is possible when the probability of a buy/sell event, compared to others, is the highest. This indicates the willingness of the seller (regulating the price of the commodity) to sell more than the other probable events. The possibilities of using the growth mechanisms presented are also true for the reduction and degradation process.

Considering price as an influencing factor in the buying/selling process, its additive growth is appropriate for structural shifts in the economy, whereas multiplicative growth is related to the capabilities of the seller, i.e. the value of the cost of production.

References

1. J.B. Oliveira, R.S. Lima, J.A.B. Simulation Modelling Practice and Theory **62** (2016)
2. Y. Wang, Y. An, F. Xi, J. Yao, Q. Wei, IOP Conf. Series **1087(062009)** (2018)
3. I.A. Gimanova, A.S. Dulesov, N.V. Litvin, IOP Conf. Series: Journal of Physics: Conf. Series **803** (2017)
4. Y. Shiozawa, Osaka City University Economic Review **24(1)** (1989)
5. Y. Shiozawa, Journal of Evolutionary Economics **30** (2020)
6. K.J. Arrow, G. Debreu, Econometrica **22(3)** (1954)
7. P. Kusev, P. van Schaik, Behavioral and Brain Sciences **36** (2013)