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Cost-based pricing model with value-added tax and corporate income tax for a supply chain network

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ABSTRACT

This article aims to propose the short-term cost-based pricing method of supply chain network with the consideration of value-added tax (VAT) and corporate income tax. First, the average cost function of each business unit in supply chain network is given, and the average cost function is taken as the monotone mapping in n-dimensional space. According to Kantorovich theorem, the existence and uniqueness of equilibrium point where the cost equals the income is discussed. When the demand function satisfies certain conditions, there generally exist many equilibrium points for cost-based pricing. Moreover, the iteration method for finding one of the equilibrium solutions is given. Then, tax burden of producers and consumers is described and illustrated with an example.

1. Introduction

Supply chain is the basic organizational structure of economic activities such as production and sales. Supply chain network can be defined as follows: the entire process in which raw material supply, production and processing, product transportation, inventory, sales of end products, as well as after-sales service provided to users, are linked.

The supply chain network usually consists of suppliers, manufacturers, warehouses, distribution centers, and dealers and so forth. Suppose the supply chain network consists of n production and business units which are denoted by n nodes correspondingly. Each production and business activity requires the investment of raw materials, fixed capital and labor hours. For instance, if a specific node represents the production activities of a certain product, the purchase of raw materials from outside the system is needed, or, the products are purchased from other nodes as the raw material input of this node; additionally, plants and equipment (fixed capital) as well as the input of labor hours are also required. If a specific node denotes the transportation activity and a certain product is transported from A (A node) to point B (B node), then the product in A place is seen as an input of transportation activities, while after its transportation to point B, the product can be considered as the output of transportation activities. Transportation vehicles, etc. can be seen as fixed capital investments, while transportation staffs are seen as the input of labor hours. So far, there have already been a great deal of literatures on the operation and management of supply chain network (for instances see [1–6]). The analysis of the production, pricing and profits at each node of the supply chain network is usually conducted according to the following steps: first, each node is treated as an independent business unit. The output at the *ith* node is q_i, which can not only represent the product quantity of a certain product produced by a specific production unit, but also the ton-kilometers of transportation offered by the transportation unit. The total cost TC_i of the *ith* node consists of the fixed cost C_i and variable cost $VC_i(q_i)$, e.g.

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$$TC_i(q_i) = C_i + VC_i(q_i), \tag{1}$$

where the fixed cost C_i is a constant, the value of variable cost is related to the output q_i. The maximization of profits π_i at each node can be described by the following equation:

$$Max \quad \pi_i = p_i q_i - TC_i(q_i). \tag{2}$$

The profits are maximized at each node in order to reach the Cournot equilibrium and to obtain the corresponding price, output and profits [7].

The above method has been adopted in many research works (see [3,8,9] for instances). However, a number of key problems remain to be solved, and further improvement is needed:

(I) How to determine the value of fixed cost C_i? Eq. (1) suggests that the fixed cost C_i is a constant, but how can it be determined according to the actual data?

In the actual production and business activities, each node requires input of fixed capital and labor hours. For instance, regardless of whether the production at the *ith* node has been started or not, the processing equipments costing K_{1i} dollar, the plant costing K_{2i} dollar, the transportation vehicles costing K_{3i} dollar and the fixed labor hours of L_i per month (suppose that the production cycle is 1 month) are needed. Then, the value volume of fixed cost measured in monetary unit is as follows:

$$C_i = (r + \delta_1)K_{1i} + (r + \delta_2)K_{2i} + (r + \delta_3)K_{3i} + wL_i, \tag{3}$$

where δ_1, δ_2, δ_3 denotes different types of fixed capital depreciation rate of this month, respectively; r denotes net return rate of fixed capital of this month; w denotes the monthly wage rate of fixed labor hours; data about the fixed capital K_{ji} and labor hour L_i can be collected in practice; then, the fixed cost C_i can be calculated according to Eq. (3). The variation of r and w can affect the value of fixed cost C_i.

(II) The public fixed capital and public service are not considered in the supply chain network above.

In practice, public infrastructures are required at each node of supply chain network, as well as the public service provided by public management sectors. Therefore, each node or management unit should pay tax as the return of public fixed capital and public service. At present, the value-added tax (VAT) and corporation income tax is imposed on enterprises and business units in China, and the tax collection affects the pricing and output quantity of each business unit.

Besides, Cournot equilibrium solution of supply chain network is generally discussed in literatures. Cournot equilibrium price is higher than the cost price, but the cost price is more reasonable, for instance see [10,11]. There are few research works on the cost-based pricing in supply chain network currently that may be nevertheless quite useful in practice. This is due to the fact that Cournot competition usually refers to output competition, e.g. each business unit calculates the output corresponding to the maximized profit in order to reach Cournot equilibrium. In actual business activities, however, the competition among various business units is usually the price competition, with each business unit determines the most favorable price according to the market. When the income of each business unit equals the cost pricing, the net return rate r_i of fixed capital and the wage rate w_i of labor hour vary for each unit. If these two rates are identical among different units, then it can be said that the entire network has reached reasonable equilibrium.

The cost-based pricing model can be applied to cost control and management in an enterprise. The production, transportation, inventory, sales and other activities of an economic entity with independent accounting (such as company, enterprise) can be described using the supply chain network model. Such an economic entity always seeks to reduce costs and increase profits. The cost-based pricing model can be used to understand which links are more sensitive to the cost of products, so as to implement management and control over the production cost. Delicacy management of the production process in an enterprise also involves product quality management apart from cost management. Only cost calculation but no quality problem is considered in this paper, that is to say, each product has only one level of quality. Castillo-Villar, K. K, Smith, N. R, & Simonton, J. L and others have made extensive researches on the cost of quality of the supply chain by establishing models (see [12–15]). On the basis of the research results above, further study can be conducted over the quality of the production process and cost management in order to benefit the modern management of an economic entity with independent accounting.

This study suggests a method of cost-based pricing of supply chain network when VAT and the corporate income tax are taken into account. Then the following conditions should be met by each business unit in this type of supply chain network: the fixed capital invested during the production process is the given constant that cannot be adjusted in a short term; thus, it is only applicable to the description of production and business activities in the short term. With the increase in output, the average cost decreases gradually. For ordinary production units, there always exists the maximum production capability. Within this capability, the above method is applicable. Especially for the production of information products with lower reproduction cost, the production capability is relatively greater, and the average cost decreases with the increase of output (see [16]). The situation of overloading in production is not included in this study. The approach suggested in this study has the following characteristics: