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Analysis of Specialized Production of Transaction Services Based on Essential Services Quantity

Li Wang, Yueting Chai*, and Yi Liu

Abstract: The specialized production of e-commerce transaction systems is an important research topic, which is of great significance for evaluating the development level and forecasting the development direction of e-commerce. However, there is a certain disparity between the current mainstream research model and reality, which leads to a deviated result. This paper puts forward a definition of “transaction efficiency” based on essential transaction services and establishes a model of the middleman’s specialized production decision of transaction services. The research result shows that (1) transaction efficiency plays an important role in improving the middleman’s specialized production level, (2) only when the transaction efficiency is higher than a certain threshold will the distribution middleman appear, and (3) the degree of economic specialization, price of commodities and transaction services, and other associated factors also affect the evolution of e-commerce transaction systems.

Key words: essential services quantity; transaction efficiency; transaction service; specialized production; optimization model

1 Introduction

In recent years and along with globalization and informatization, e-commerce has played a more important role in the world’s economic system and has become the basis of new economic growth in many countries. At present, there are various e-commerce and corresponding transaction system structures. In addition to producers and consumers, third party transaction platforms, logistics service providers, and payment institutions also play important roles in these e-commerce models. They provide commodity circulation services in order to realize the trade of commodities and we call these players “middlemen”. Different kinds of middlemen populate e-commerce transaction systems. The structure of the e-commerce market is shown in Fig. 1.

In terms of business model and profit-making means,

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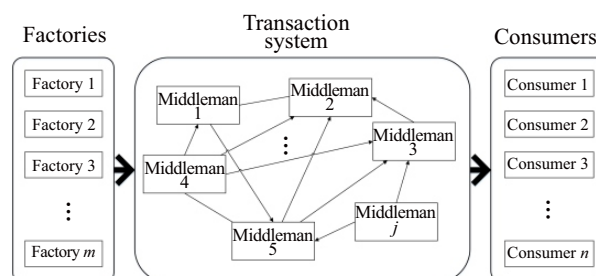


Fig. 1 Structure of the e-commerce market.

middlemen can be categorized into two types. The first type does not have the ownership of commodities, but provide transaction services and earn a profit by selling their services to others, such as e-commerce platforms providing channels for sellers to show their commodities and consumers to express their opinions^[1], logistics companies providing logistics services, banks and other payment companies providing methods to finish payments, and so on. The second type has ownership of commodities and earns a profit by selling those commodities to others. They organize the transaction themselves and use the information, logistics, and payment services provided by the first type, such as importers and exporters, to close the

deal. A. D. Chandler called the former “commission middlemen” and the latter “markup middlemen”^[2]. In the current e-commerce environment, these terms have limitations; therefore according to the two types of traded objects, we call the former “service middlemen” and the latter “distribution middlemen”.

In fact, the specialized production of middlemen is more complicated. A middleman can be a service middleman as well as a distribution middleman as long as they sell both services and commodities, like Amazon selling commodities and providing information and logistics services. A middleman can sell more than one kind of service, like Alibaba selling information, logistics, and payment services. However, a lot of middlemen only produce and sell only one kind of service.

This makes us curious about the evolution of specialized production in e-commerce transaction system. How many types of middlemen will exist in the future? What services will they provide? To tackle these questions, this paper studies the laws of specialized production and evolution laws in e-commerce transaction systems.

The study of specialized production has a long history. In the 18th century, Smith and Nicholson^[3] put forward the origin of the specialized production in *An Inquiry into the Nature and Causes of the Wealth of Nations*. They believed that different producers have different production efficiencies to produce different products, which forms the absolute advantage of producers; hence, producers produce the products in which they have an absolute advantage, thus, the division of labor appears. On the basis of Smith and Nicholson^[3], Ricardo^[4] proposed the theory of comparative advantage. He thought absolute advantage is not the necessary condition for trade. Producers could just produce the commodities with more advantages than other commodities to benefit from the specialized production and trade. Eli Heckscher and Bertil Ohlin developed the *Heckscher-Ohlin Theorem*. They thought that differences between the abundance and the price of production factors in different countries lead to different prices of commodities before trade, resulting in the division of labor and trade between different countries^[5]. Yang^[6] deemed that the level of specialized production is determined by the conflict between incomes and transaction costs brought by the specialized production. As long as the increased benefits outweigh the transaction costs, the level of

specialized production will improve. Sun et al.^[7] proposed a model based on reachable transaction scope to show that with the expansion of reachable transaction scope, the firm develops from a low-investment direction into the specialized direction.

The rest of this paper is structured as follows. Section 2 reviews the development of transaction costs and transaction efficiency and gives a new definition of “transaction efficiency”. Section 3 builds a model of middlemen’s specialized production decisions. Section 4 solves the model built in Section 3 and analyzes the results to explore the relationships between specialized production and related factors. Finally, Section 5 draws conclusions from the results.

2 Transaction Efficiency

2.1 An overview of transaction costs and transaction efficiency

In this paper, transaction efficiency is regarded as the dynamic of the evolution of specialized production in e-commerce transaction systems and that the concept of transaction efficiency is evolved from transaction costs.

The idea of transaction costs was first proposed by Coase^[8]. He thought transaction costs include the cost of discovering what the relevant prices are and the costs of negotiating and concluding a separate contract for each exchange transaction in a market. Williamson^[9] further developed transaction cost theory based on Coase’s work. He proposed three key concepts in transaction cost theory—assets specificity in technical issues, bounded rationality regarding human nature, and opportunistic behavior to explain what causes transaction costs. Cheung^[10] defined transaction costs to be all the costs that do not exist in a “Robinson Crusoe” economy. Until now, researchers’ views about transaction costs have not been unanimous. Different researchers came up with different definitions of transaction costs from different perspectives.

However, transaction cost is a comprehensive concept, which makes it difficult to quantify when analyzing economic problems. Garicano and Kaplan^[11] divided transaction costs into coordination costs and motivation costs. den Butter and Mosch^[12] pointed out that transaction costs in trade not only comprise traditional costs associated with transportation (distance), trade barriers, tariffs, etc. but also search costs, costs on gathering information of product quality and the reliability of the trading partner, legal costs, control costs, and costs associated with

international payments. Duan^[13] considered the idea that transaction costs' attributes can be identified from three measures: assets specificity, uncertainty, and transaction frequency. Li and Chen^[14] thought that transaction costs consist of transportation costs, inventory costs, negotiation costs, risk costs, and information costs. In this background, the economists represented by Yang^[6] put forward the concept of transaction efficiency.

Yang^[6] used Samuelson's Iceberg Transport Cost model to define transaction efficiency. When a buyer purchases one unit of product, he can only get k unit of product, where $1 - k$ unit of product melts during the transaction process. The $1 - k$ unit of product could be deemed as transaction costs, which include the costs of transportation, implementation of transaction, storage, payment, and so on. Thus, k could be considered as the transaction efficiency. Sheng^[15] defined transaction efficiency as the ratio between transaction gains and transaction expenses. Ma^[16] believed transaction efficiency refers to the volume or number of transactions implemented when certain transaction essential factors are involved under the constraints of an existing system and other technical conditions. Gao^[17] thought transaction efficiency is the contrast between the revenue of division of labor and transaction costs.

2.2 Transaction efficiency based on essential services quantity

The above definitions indicate researchers' hope of associating transaction costs with prices and costs of commodities. Although transaction efficiency is related to the characteristics of commodities, making such an idea capable of expressing the level of transaction to some extent still creates some problems. The prices of commodities are influenced by supply and demand in the market. For one kind of commodity, price changes in different periods, and the transaction efficiency should change at the same time. However, the transaction efficiency of one kind of commodity does not change, which leads to a contradiction. Therefore, transaction efficiency should be measured by the quantity of transaction services instead of the price of transaction services.

To define transaction efficiency, we put forward a concept — essential service quantity.

Definition 1 Essential services quantity is the quantity of services needed to complete a transaction. The minimum essential services quantity is 1.

In other words, the essential services quantity is a real number no less than 1.

Based on the definition of essential services quantity, we define transaction efficiency as follows.

Definition 2 The transaction efficiency of a transaction system is the ratio of minimum essential services quantity to the essential services quantity of the transaction system.

Let sq be essential services quantity and k be transaction efficiency, then we have

$$k = \frac{1}{sq}.$$

Because $sq \geq 1$, we have $0 < k \leq 1$, i.e.,

$$k \in (0, 1].$$

From the definition, we can see that the minimum essential services quantity is the essential services quantity of the transaction system whose transaction efficiency is 1, and it is the most ideal transaction system.

We believe that essential services quantity is mainly related to four factors: transaction distance, transaction time, commodity characteristics, and transaction system. The longer the transaction distance the harder it is to finish the transaction and the more transaction services needed. The shorter the transaction time the more transaction services are needed. The harder the commodity characteristics and transaction system make the transaction the more transaction services are needed. Therefore, through the quantification of transaction distance, transaction time, commodity characteristics, and transaction system, essential services quantity can be expressed as the function of transaction distance, transaction time, commodity characteristics, and transaction system, i.e.,

$$sq = sq(td, tt, cc, ts),$$

where td is the transaction distance, tt is the transaction time, cc is the commodity character, and ts is the transaction system.

We shall not discuss the concrete form of the function of essential services quantity and transaction efficiency in this paper. We will use the definitions of essential services quantity and transaction efficiency in this study.

3 Problem Description and Model

3.1 Problem description

This study will focus on the decision problems in the production and trade of transaction services of

a middleman with constant resources. We assume there is one kind of commodity traded in the market and that supply of the commodity is unlimited. To complete a transaction, four kinds of transaction services are needed, namely, organizing transaction, information, logistics, and payment services. The quantities demanded of the services above are the same as in a transaction, i.e., the ratio is 1:1:1:1.

A middleman chooses one to four kinds of transaction services to provide. If a middleman wants to sell the commodities as a distribution middleman, then he has to produce organizing transaction services, which are not allowed to trade. The quantity of commodities sold by a middleman depends only on the quantity of organizing transaction services produced by the middleman. However, information, logistics, and payment services are allowed to trade. When a middleman sells commodities, he should ensure the quantity of information, logistics, and payment services are no less than the one of organizing transaction services. Thus, if any kind of the three kinds of services above produced by the middleman is less than the organization transaction services, then he has to buy the corresponding kind of services to meet the requirements. On the contrary, if any kind of the three kinds of services above produced by the middleman is more than the organization transaction services, then he could sell the surpluses.

3.2 Model

Let $w, x, y,$ and z be the quantities of organizing transaction services, information services, logistics services, and payment services, respectively. The production functions of transaction services are as follows:

$$w = l_w^a, x = l_x^b, y = l_y^c, z = l_z^d,$$

where $a, b, c,$ and d are the degrees of economic specialization for organizing transaction services, information services, logistics services, and payment services, respectively. We believe that there are increasing returns to scale in the production of transaction services. Thus, we have

$$a > 1, b > 1, c > 1, d > 1.$$

Let $l_i \in [0, 1](i = w, x, y, z)$ be the resource used to produce the service i . We think the total resource of a middleman is constant and we let it be 10, so we have

$$l_w + l_x + l_y + l_z = 10.$$

Let N be the quantity of commodity sold by a

middleman, then

$$N = \frac{w}{s} = wk,$$

where s is the essential services quantity and k is the transaction efficiency.

If $i \geq w (i = x, y, z)$, then the middleman has $i - w$ units of transaction services to sell. If $i \leq w (i = x, y, z)$, the middleman has to buy $w - i$ units of transaction services. The profit function is

$P = p_c N + p_x(x - w) + p_y(y - w) + p_z(z - w)$, where $p_c, p_x, p_y,$ and p_z are the prices of the commodity, information services, logistics services, and payment services, respectively. The prices of commodity and transaction services are affected by supply and demand. The higher the supply, the lower the price is. The higher the demand, the higher the price is. The price function of the commodity is as follows:

$$p_c = g_c - h_c N.$$

The price functions of transaction services are as follows:

$$p_i = g_i - h_i(i - w), \quad i = x, y, z.$$

The optimal specialized production mode decision problems of a middleman are as follows:

$$\max P = p_c N + p_x(x - w) + p_y(y - w) + p_z(z - w),$$

$$\text{s.t.} \begin{cases} w = l_w^a, & x = l_x^b, \\ y = l_y^c, & z = l_z^d, \\ l_w + l_x + l_y + l_z = 10, \\ p_c = g_c - h_c N, \\ p_x = g_x - h_x(x - w), \\ p_y = g_y - h_y(y - w), \\ p_z = g_z - h_z(z - w), \\ N = wk, \\ 0 \leq k \leq 1. \end{cases}$$

To simplify the model, we think that the degrees of specialization economy of information service, logistics service, and payment service economy are the same, i.e.,

$$a = b = c = d.$$

Meanwhile, the price functions of information, logistics, and payment services are the same. The gradients of transaction services price functions and commodity price function also are the same, i.e.,

$$g_x = g_y = g_z, \\ h_c = h_x = h_y = h_z.$$

Thus, the decision problem can be rewritten as follows:

$$\max P = p_c N + p_x(x - w) + p_y(y - w) + p_z(z - w),$$

$$\text{s.t.} \begin{cases} w = l_w^a, & x = l_x^a, \\ y = l_y^a, & z = l_z^a, \\ l_w + l_x + l_y + l_z = 10, \\ p_c = e - hN, \\ p_x = g - h(x - w), \\ p_y = g - h(y - w), \\ p_z = g - h(z - w), \\ N = wk, \\ 0 \leq k \leq 1. \end{cases}$$

4 Solution, Results, and Discussion

4.1 Solution of the model

To solve the model, we substitute the constraints into the model, and obtain

$$\begin{aligned} P &= p_c wk + [g - h(x - w)](x - w) + \\ & [g - h(y - w)](y - w) + [g - h(z - w)](z - w) = \\ & (e - hkl_w^a)kl_w^a + [g - h(l_x^a - l_w^a)](l_x^a - l_w^a) + \\ & [g - h(l_y^a - l_w^a)](l_y^a - l_w^a) + [g - h(l_z^a - l_w^a)](l_z^a - l_w^a) = \\ & -h[(k^2 + 3)l_w^{2a} + l_x^{2a} + l_y^{2a} + l_z^{2a}] + \\ & (ek - 3g)l_w^a + (g + 2hl_w^a)(l_x^{2a} + l_y^{2a} + l_z^{2a}). \end{aligned}$$

Thus, the last constraint is

$$l_w + l_x + l_y + l_z = 10,$$

which is an equality constraint. Therefore, we can introduce the Lagrange multiplier to change the above constrained maximization problem into an unconstrained maximization problem. The new objective function is

$$\begin{aligned} P_\lambda &= -h[(k^2 + 3)l_w^{2a} + l_x^{2a} + l_y^{2a} + l_z^{2a}] + \\ & (ek - 3g)l_w^a + (g + 2hl_w^a)(l_x^{2a} + l_y^{2a} + l_z^{2a}) + \\ & \lambda(10 - l_w - l_x - l_y - l_z), \end{aligned}$$

where λ is the Lagrange multiplier. Obviously, the total revenue P_λ has the partial derivatives with respect to $l_w, l_x, l_y, l_z,$ and λ . Taking the partial derivatives, we get the first-order condition of the problem:

$$\begin{aligned} \frac{\partial P}{\partial l_w} &= -2ah(k^2 + 3)l_w^{2a-1} + \\ & a[ek - 3g + 2h(l_x^a + l_x^a + l_x^a)]l_w^{a-1} - \lambda = 0, \\ \frac{\partial P}{\partial l_x} &= -2ahl_x^{2a-1} + a(g + 2hl_w^a)l_x^{a-1} - \lambda = 0, \\ \frac{\partial P}{\partial l_y} &= -2ahl_y^{2a-1} + a(g + 2hl_w^a)l_y^{a-1} - \lambda = 0, \\ \frac{\partial P}{\partial l_z} &= -2ahl_z^{2a-1} + a(g + 2hl_w^a)l_z^{a-1} - \lambda = 0, \\ \frac{\partial P}{\partial \lambda} &= 10 - (l_x^a + l_x^a + l_x^a) = 0. \end{aligned}$$

As we can see, because $a > 1$, the equations are of higher degree, making it difficult to get the analytic solution. Thus, in this paper, the author will use a numerical solution to study the specialized production of middlemen.

4.2 Results and discussion

In this paper, we use the uncorrected sample standard deviation of the resource used to produce four kinds of services to measure specialized production levels. A higher sample standard deviation means a higher specialized production level. (Here, choosing uncorrected sample standard deviation or corrected sample standard deviation does not matter because we just want to measure specialized production levels instead of getting an accurate estimate.)

Let s be the uncorrected sample standard deviation of the resource used to produce four kinds of services:

$$s = \sqrt{\frac{1}{4} \sum_{i=w,x,y,z} (l_i - \bar{l})^2}.$$

Here, \bar{l} denotes the mean of the resource used to produce four kinds of services,

$$\bar{l} = \frac{1}{4} \sum_{i=w,x,y,z} l_i = 2.5.$$

We believe that the promotion of transaction efficiency is the dynamic of middlemen's specialized production evolution and that other parameters of the model have different effects on the evolution. Therefore, we will study the influence of the promotion of transaction efficiency on middlemen's specialized production evolution with different parameters.

4.2.1 Effect of degree of economic specialization

Degree of specialization economy reflects the middlemen's production level of transaction services. Take the other parameters as follows:

Commodity equilibrium price $e = 2000$;

Transaction services equilibrium price $g = 300$;

Price gradient $h = 2$.

Different degrees of economic specialization affect the evolution as shown in Figs. 2–6.

Through the above results, we can see that with the improvement of transaction efficiency, specialized production of transaction services appears. However, the changes of specialized production levels are not monotonic.

The uncorrected sample standard deviation shock between different values occurs when transaction

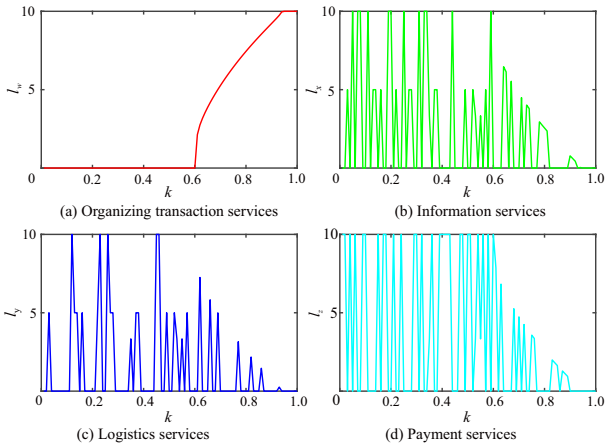


Fig. 2 Degree of economic specialization $a = 1.8$.

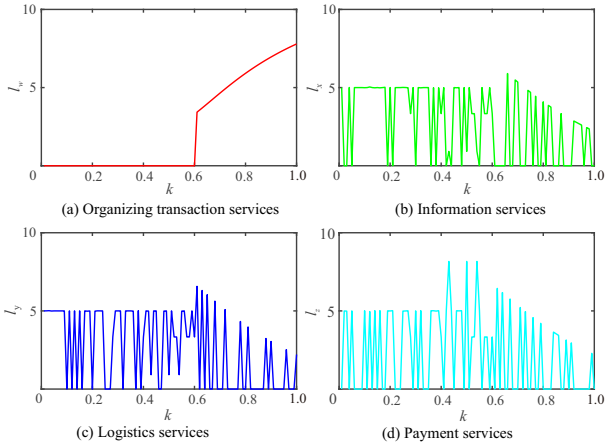


Fig. 3 Degree of economic specialization $a = 2$.

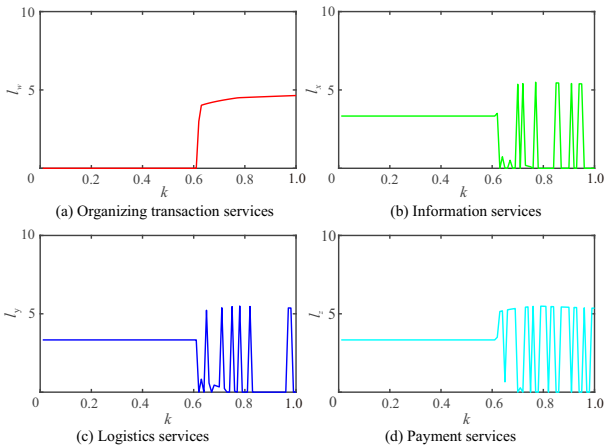


Fig. 4 Degree of economic specialization $a = 3$.

efficiency is low, shown in Fig. 7, and the changes of specialized production levels are not clear.

When transaction efficiency reaches a certain threshold and the essential transaction services to complete transactions decline, the profit margin of trading commodities climbs and the distribution middlemen appear. Middlemen do not select all

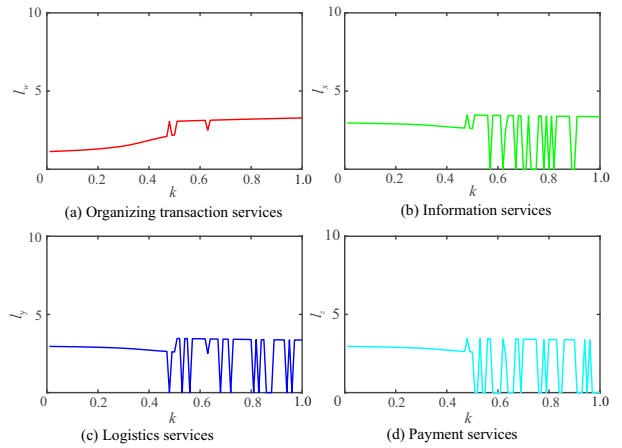


Fig. 5 Degree of economic specialization $a = 4$.

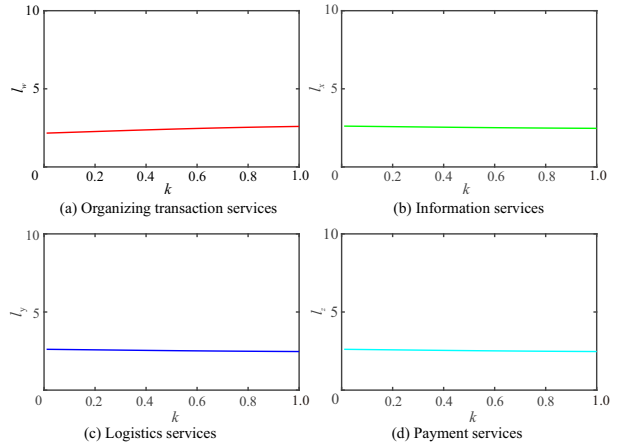


Fig. 6 Degree of economic specialization $a = 5$.

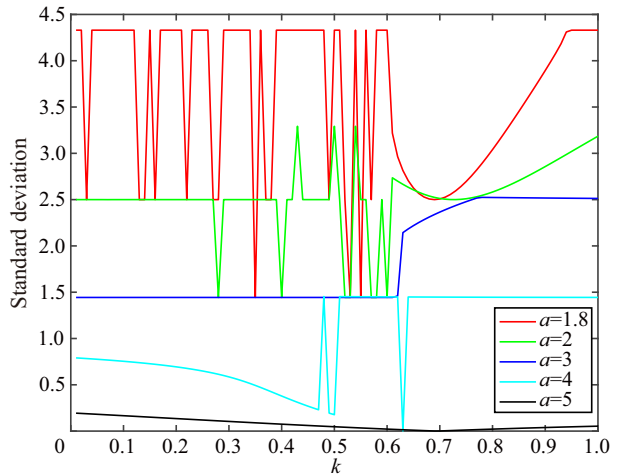


Fig. 7 Uncorrected sample standard deviations of different degrees of economic specialization.

information, logistics, and payment services to produce and purchase the transaction services that they do not produce from the market to meet their own needs; however, the specialized production is not thorough.

From the uncorrected sample standard deviation,

we can see that with the rising degree of economic specialization, the level of specialized production gradually declines. When the degree of economic specialization $a = 5$, the uncorrected sample standard deviation approximates 0 and the transaction efficiency nearly has no effect on the change of the specialized production because with a high degree of economic specialization the middlemen's production capacity is much greater than the market demand. Thus, there is no need for middlemen to specialize in production.

4.2.2 Effect of price gradient

The price gradient reflects the level of price affected by supply and demand. Take the other parameters as follows:

- Degree of economic specialization $a = 3$,
- Commodity equilibrium price $e = 2000$,
- Transaction services equilibrium price $g = 300$.

Different price gradients affect the evolution as shown in Figs. 8–11.

Through Figs. 8–11, we can see that with the

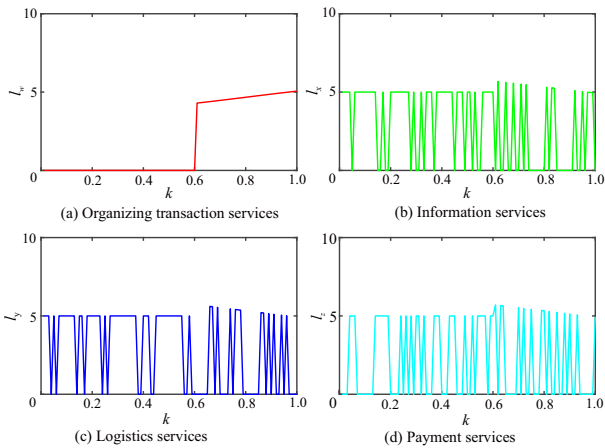


Fig. 8 Price gradient $h = 1$.

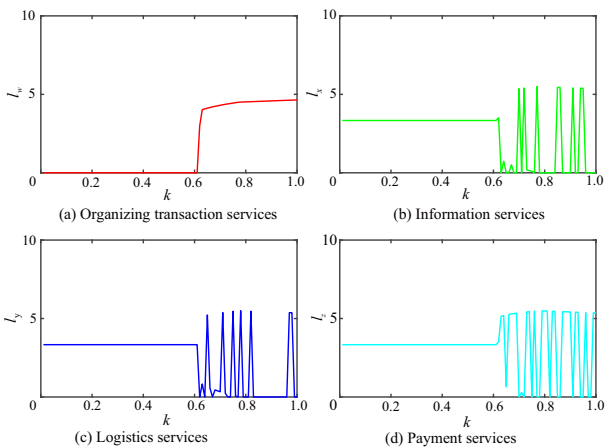


Fig. 9 Price gradient $h = 2$.

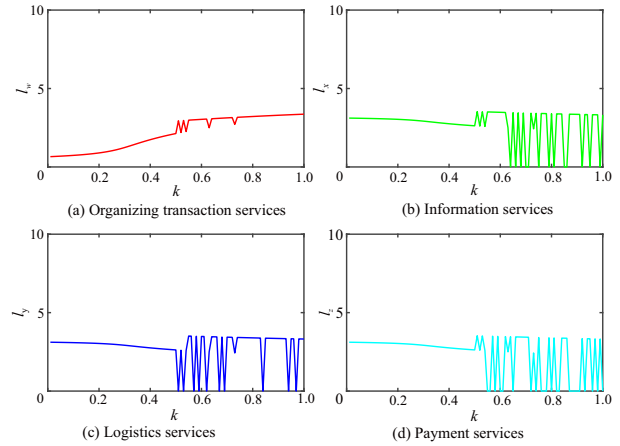


Fig. 10 Price gradient $h = 5$.

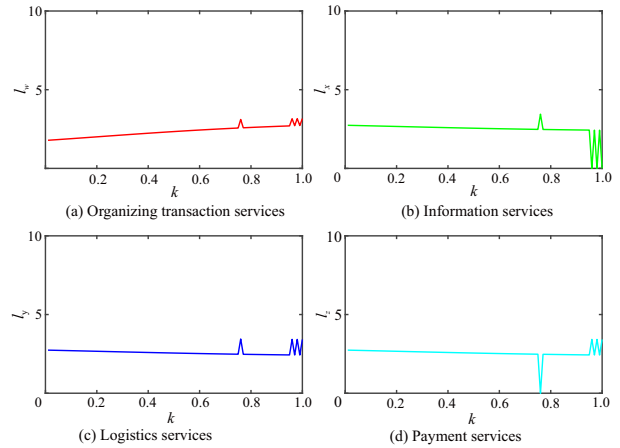


Fig. 11 Price gradient $h = 10$.

improvement of transaction efficiency, the specialized production of transaction services production appears.

When transaction efficiency is low, middlemen invest almost the same resources to produce information, logistics, and payment services in most cases.

When transaction efficiency reaches a certain threshold, the essential transaction services needed to complete transactions decline, the profit margin of trading commodities goes up, and distribution middlemen appear. Middlemen do not select all kinds of information, logistics, and payment service to produce and purchase the transaction services that they do not produce from the market to meet their own needs. However, the uncorrected sample standard deviation shock between different values means that the specialized production levels change frequently, as shown in Fig. 12.

With a low price gradient, middlemen's specialized production levels of information, logistics, and payment services become higher as the service price is not

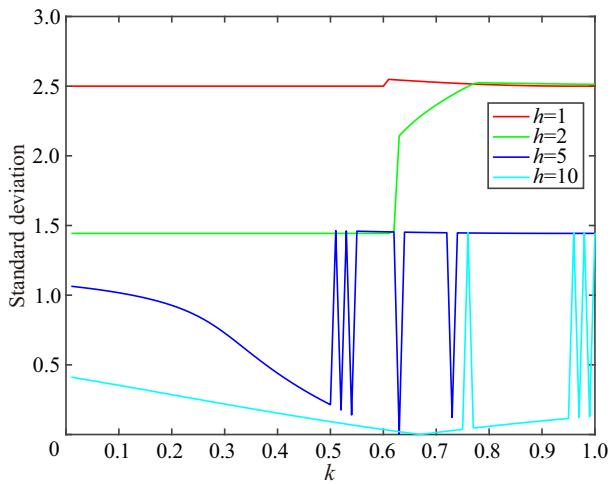


Fig. 12 Uncorrected sample standard deviations of different price gradients.

affected much by production. The mass production led by specialization still can make middlemen maintain a higher level of profit. Conversely, with a high price gradient, middlemen’s specialized production levels of information, logistics, and payment services decline due to mass production, resulting in a fall in unit price and, hence, reduced profits. At the same time, middlemen’s demands of other services increase, leading to the rise of other services’ prices as well as the costs of middlemen in purchasing other services. However, different price gradients have no effect on the value of transaction efficiency k when distribution middlemen appear.

4.2.3 Effect of relative equilibrium price

Relative equilibrium price refers to the ratio of goods equilibrium price and transaction services equilibrium price e/g . Here we fix services equilibrium price and change the commodity price to change the relative equilibrium price. Take the other parameters as follows:

- Degree of economic specialization $a = 3$,
 - Price gradient $h = 2$,
 - Transaction services equilibrium price $g = 300$.
- Different relative equilibrium prices affect the evolution, as shown in Figs. 13–16.

The results shown in Figs. 13–16 indicate that with the improvement of transaction efficiency, the specialized production of transaction services production appears.

When transaction efficiency is low, middlemen invest almost the same resource to produce information, logistics, and payment services. Specialized production is also at a low level.

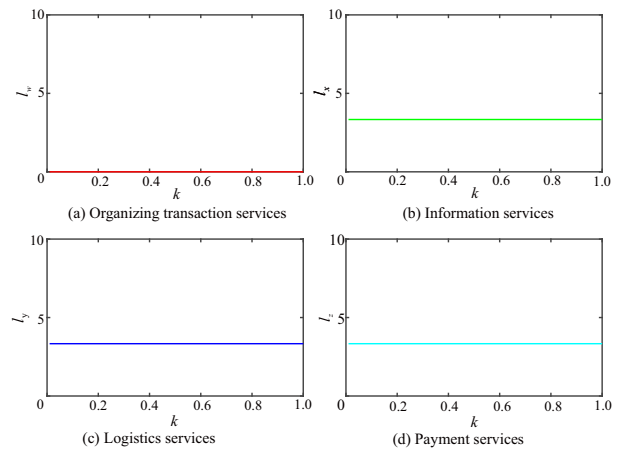


Fig. 13 Commodity equilibrium price $e = 1000$.

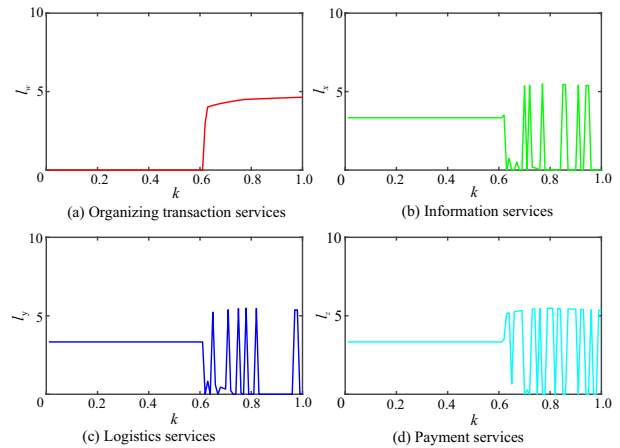


Fig. 14 Commodity equilibrium price $e = 2000$.

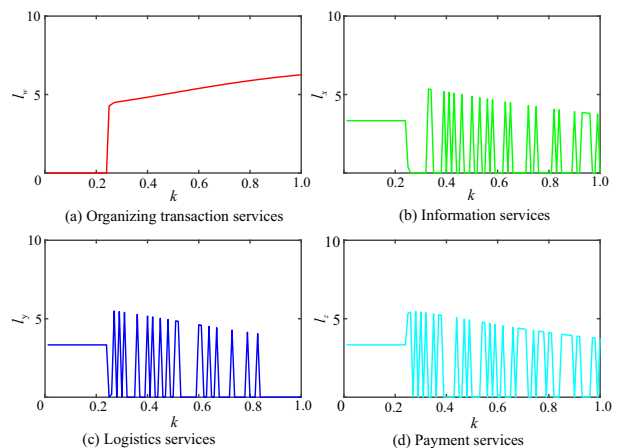


Fig. 15 Commodity equilibrium price $e = 5000$.

When transaction efficiency reaches a certain threshold, the essential transaction services to complete transactions decline, the profit margin of trading commodities goes up, and the distribution middlemen appear. Middlemen do not select all information, logistics, and payment services to produce and purchase

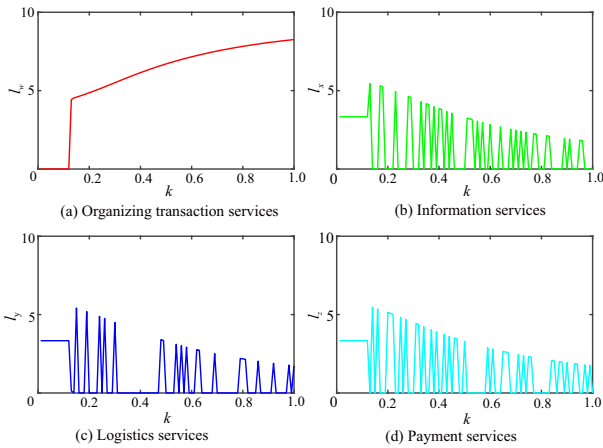


Fig. 16 Commodity equilibrium price $e = 10\ 000$.

the transaction services that they do not produce from the market to meet their own needs. The specialized production levels climb up monotonously as the transaction efficiency rises.

From the uncorrected sample standard deviation, shown in Fig. 17, we can see as the relative equilibrium price e/g increases, the value of transaction efficiency k decreases when distribution middlemen appear due to the higher relative equilibrium price; thus, the profit of selling commodities is greater than that of selling transaction services, which causes the appearance of distribution middlemen. The specialized production of transaction services happens at the same time.

5 Conclusion

In this paper, according to the characteristics of the transaction system, we put forward the concept of essential services quantity and present a new definition

of “transaction efficiency”. On this basis, we set up a decision model of middlemen’s transaction services specialized production. The model’s optimization goal is the profit of middlemen. Compared with other models, it is more realistic. Meanwhile, we consider the influence of services’ supply and demand on prices, which reflects the characteristics of the market well. Due to the higher degree of equations, we use the numerical solution instead of the analytic solution to explore the effect of transaction efficiency on middlemen’s specialized production evolution and the effect of the degree of economic specialization, the price gradient and the relative equilibrium price on the results.

The results show that with the improvement of transaction efficiency, the specialized production of transaction services production appears. When transaction efficiency is low, middlemen invest almost the same resources to produce information, logistics, and payment services. When transaction efficiency reaches a certain threshold, the essential transaction services to complete transactions decline, the profit margin of trading commodities goes up, and distribution middlemen appear. Middlemen do not select all information, logistics and payment services to produce and purchase the transaction services that they do not produce from the market to meet their own needs. In addition, the degree of economic specialization and the price gradient affect middlemen’s specialized production levels, and the relative equilibrium price of commodities and services affects the value of transaction efficiency when distribution middlemen appear.

However, in this model, the thorough specialized production does not appear. Even if the transaction efficiency reaches 1, middlemen will still produce at least two kinds of transaction services. This is because the natures of the transaction services and commodities are different. The demand of commodities is independent of transaction services, while the demand of transaction services is dependent on the sales volume of commodities. If the market for the transaction services exceeding the sales volume of commodities is not big enough, then there are no profits to middlemen. Specialized production has the advantage of higher production levels; however, too much output will not bring the corresponding profits for middlemen. Thus, middlemen will lose motivation for specialized production; that is, the specialized

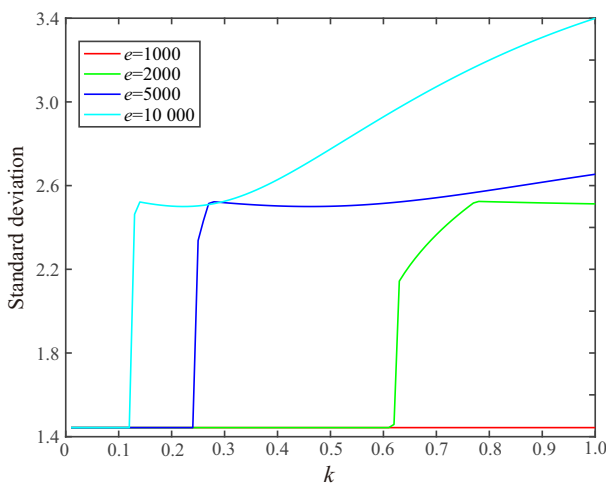


Fig. 17 Uncorrected sample standard deviations of different commodity equilibrium prices.

production levels of transaction services are limited by the capacity of the market.

This research provides a theoretical basis for the evolution of the e-commerce model. In the future, the specialized production level of e-commerce will be further enhanced; however, the thorough specialized production pattern will not appear. E-commerce middlemen will explore the diversified production models combined with the market situation. The future e-commerce model will be a balance between specialization and diversification.

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