The Network Effect and Information Sharing of Cross-Border e-Commerce: Manufacturers' Productivity and Decisions

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Manuscript submitted June 12, 2018; accepted September 14, 2018.
doi: 10.17706/ijeeee.2019.9.4.277-284

Abstract: The development of e-commerce platforms has resulted in changes in consumer behavior. Studies have also proven that e-commerce platforms could provide benefits to customers, such as the network effect and information sharing. With reference to existing research, this study extended the framework of the model proposed by Melitz (2003) and discovered that the zero cutoff profit (ZCP) curve and cross-border ZCP curve divided the area of the most likely combination of productivity levels into three regions. In addition, a combination of productivity levels closer to the upper-right corner indicates that the company is more capable of providing cross-border e-commerce services. If the consumer demand index of cross-border e-commerce platforms is different between two countries, then the country with the better cross-border e-commerce platforms is more likely to generate a network effect and increase information sharing among cross-border consumers, thereby helping the manufacturers to export more products and obtain higher profits.

Key words: Cross-border e-commerce, information sharing, network effect, productivity.

1. Introduction

The advent of the Internet era has made people highly dependent on the Internet. Data shows that an increasing number of individuals have shifted the focus of their interpersonal development to online interaction, which has raised the significance of the network effects and increased information sharing through e-commerce platforms. Past studies on e-commerce platforms tend to focus on consumer psychology, but very few studies have investigated cross-border e-commerce platforms from the perspective of manufacturers. Therefore, this study aimed to explore the subject from the manufacturer's viewpoint, so as to provide a reference for governments and enterprises, as well as further improve theories related to cross-border e-commerce platforms.

The development of e-commerce platforms has led to changes in consumer behavior. One such example is the social networking function of e-commerce platforms. In addition to providing consumers with a better understanding of products through a product-review function, e-commerce platforms give consumers the opportunity to expand their social network, and thereby obtain benefits beyond the utility of the products. Kim and Srivastava [1] proposed that consumers' purchase decisions are substantially influenced by other consumers and individuals that they trust. Trusov *et al*. [2] discovered that one fifth of social media users' friends have an actual influence on their online activity level. Using social cognition theory and social capital

theory, Chiu *et al*. [3] found that many aspects of social capital tend to affect individuals' information sharing behavior on social network platforms. In addition, sharing of information through online platforms also has a significant impact on business operations. Yu *et al*. [4] pointed out that systematic monitoring and control of business-consumer interaction and information sharing among consumers over the Internet of things (IoT) is crucial to enterprises. Moreover, users' e-satisfaction and attitudes towards the website play an important role in maintaining their loyalty.

The development of e-commerce platforms has brought tremendous change in both consumers and manufacturers. On that account, this study attempted to examine e-commerce platforms from the perspective of manufacturers' productivity and decision-making processes, which are rarely covered by existing studies. A small number of recent studies do confirm the necessity of such an approach. Ortega *et al*. [5] suggested that the development and popularity of e-commerce has caused considerable change in the production function of enterprises. Based on data of firms of various sizes and from different sectors in Chile, they further analyzed the impact of e-commerce adoption on the productivity of these firms in the context of a middle-income economy. The results show a close correlation between e-commerce and the productivity of manufacturing and service industries. In addition, online buying behavior was found to be the key channel for this correlation. Therefore, referring to the studies of Hallak and Sivadasan [6] and Aw and Lee [7], this article intends to extend the framework of the model proposed by Melitz [8], by introducing the heterogeneity of technical efficiency and demand index into the model. According to the generated graph, the area of likely combination of productivity was divided into three regions with the ZCP curve and cross-border ZCP curve. In addition, a combination of productivity levels closer to the upper-right corner was found to indicate that the company is more capable of providing cross-border e-commerce services. Furthermore, if the consumer demand index of a given cross-border e-commerce platform was different between two countries, the combined area of technical efficiency and demand index was divided by the cross-border ZCP curve into four regions. When technical efficiency of the two countries remained the same, the country with better cross-border e-commerce platforms was determined to be more likely to generate a network effect and information sharing among cross-border consumers, which thereby helps the manufacturers to export more products and obtain higher profits.

The following sections are divided as follows: Section 2 introduces the theoretical framework of the study, section 3 discusses the differences in demand index between nations, and section 4 presents the conclusions.

2. Theoretical Framework

Extending the framework from the model proposed by Melitz [8], this study included heterogeneity of two variables: technical efficiency and demand index. Technical efficiency is generated through manufacturers' production capacity, which is expressed as the reciprocal of the unit cost of a given product. The consumer demand index reflects consumer preferences. Aw and Lee [7] defined consumer demand as consumers' preferences for product quality or brand name. This study further extended this definition and defined consumer demand as consumers' level of confidence and trust toward purchasing a product, and its after-sale service, due to the network effect, information sharing, and feedback on a given cross-border e-commerce platform. Moreover, by expanding the definition of productivity, we further discussed the impact of the network effect, information sharing, and feedback of cross-border e-commerce on the decision-making behavior of international manufacturers.

2.1. Preferences

To satisfy the abovementioned assumption that consumers' confidence in a product and trust in its after-sales services is influenced by the network effect, information sharing, and feedback of cross-border

e-commerce platforms, the demand index (a_i) was expressed by a Cobb-Douglas production function, $a_i(\kappa,\psi) \equiv \kappa^{\gamma}\psi^{\eta}, \gamma \in [0,1], \eta \in [0,1]$. κ denotes the network effect and information sharing, and ψ denotes the feedback of cross-border e-commerce platforms; γ and η represent the impact of the network effect and information sharing, respectively, on changes in consumer demand. In addition, the consumer utility rate was defined as being the continuous consumption of a series of different products from a given industry, purchased through cross-border e-commerce platforms, and is expressed as follows:

$$U = \left\{\int_{i\in I} [a_i(\kappa,\psi)q_i]^{\rho} di\right\}^{\frac{1}{\rho}}, \rho \in (0,1) \tag{1}$$

where $a_i(\kappa,\psi)$ is the demand index for the product of a specific manufacturer on cross-border e-commerce platforms, and $q(i)$ represents the quantity of products in category i that are consumed. I signifies the sum of all the likely product categories. In addition, we assumed that the alternative elasticity between product categories is a fixed value ε ($\varepsilon \geq 1$), and $\varepsilon = 1/(1-\rho)$. Moreover, considering the maximum utility rate with a limited budget of the consumer ($\int_{i\in I} p_i q_i di = R$), the demand of product category i can be expressed as follows:

$$\hat{q}_i = R\hat{P}^{\varepsilon-1}(\hat{p}_i)^{-\varepsilon} \tag{2}$$

where $\hat{q}_i \equiv a_i(\kappa,\psi)q_i$ is defined as the quantity after adjusting for the demand index for i (demand-index-adjusted quantity), and $\hat{p}_i \equiv p_i/a_i(\kappa,\psi)$ is defined as the price after adjusting for the demand index for i (demand-index-adjusted price). In addition, $\hat{P} = [\int_{i\in I} [p_i/a_i(\kappa,\psi)]^{1-\varepsilon} di]^{\frac{1}{1-\varepsilon}}$ signifies the composite price index of the entire collection of cross-border e-commerce platforms after adjusting for the demand index of i. R represents the aggregate expenditure of a given industry of cross-border e-commerce platforms.

2.2. Production

The technical efficiency of a given manufacturer is defined as $\mu \in (1,\infty)$, the unit cost of a product is defined as p_μ; then, the cost of producing one product unit can be expressed as $1/\mu$. Thus, the total cost can be expressed as follows:

$$TC_i = F + \frac{p_\mu a_i^{\vartheta}}{\mu_i} q_i \tag{3}$$

Suppose $\varphi_i \equiv \mu_i a_i^{1-\vartheta}$ denotes the productivity of a given manufacturer; ϑ ($0 < \vartheta < 1$) represents the elasticity of the production costs, which is defined as a constant value that is consistent between manufacturers. Therefore, when the value of the elasticity increases, the increase in production costs tends to be more substantial. Furthermore, F is defined as the fixed operating costs of the manufacturers.

2.3. Cross-Border e-Commerce

In consideration of the setting for cross-border e-commerce, this study assumed that there were only two countries in the world. Moreover, exporting products to other countries involves tariffs and transportation costs. Manufacturers that have the ability to export products also need to pay a fixed cost (fixed export cost) in order to enter the target market, which is represented by F_x. The iceberg transport cost model was

introduced. We assume $\tau \geq 1$, which means that out of τ units of products, only one unit reaches the target market. The above cost context characteristics apply to all manufacturers with consideration of product quality.

2.4. Profit Maximization

Within the framework of heterogeneous firms, and considering technical efficiency and the demand index, the conditions for profit maximization are as follows:

$$\max_{p_i, p_{i,x}} \pi_i(a, \varphi) = \left[\left(p_i - \frac{p_\mu a_i^\vartheta}{\mu_i}\right) q_i - F\right] + \Gamma_x \left[\left(p_{i,x} - \frac{\tau p_\mu a_i^\vartheta}{\mu_i}\right) q_{i,x} - F_x\right] \tag{4}$$

According to (4), $\Gamma_x = 1$ indicates that the manufacturer supplies to both domestic and foreign markets, while $\Gamma_x = 0$ means that the manufacturer only supplies to the domestic market. p_i and $p_{i,x}$ denote the prices of *i* in the domestic and foreign markets, respectively; q_i and $q_{i,x}$ denote the demands of *i* in the domestic and foreign markets, respectively. Based on the conditions of profit maximization, the optimal price of i can be expressed as follows:

$$p_i = \frac{p_\mu a_i^\vartheta}{\rho \mu_i};\ p_{i,x} = \frac{\tau p_\mu a_i^\vartheta}{\rho \mu_i} \tag{5}$$

Based on (5), the returns and profits of *i* for providing services to domestic and foreign customers on cross-border e-commerce platforms, after adjusting for the demand index, can be obtained as follows:

$$\tilde{r}_i(a, \mu) = R\left(\hat{P}\right)^{\varepsilon - 1} \left[\frac{p_\mu a_i^{\vartheta - 1}}{\rho \mu_i}\right]^{1-\varepsilon};\ \tilde{r}_x(a, \mu) = R_f\left(\tilde{P}_f\right)^{\varepsilon - 1} \left[\frac{\tau p_\mu a_i^{\vartheta - 1}}{\rho \mu_i}\right]^{1-\varepsilon} \tag{6}$$

and

$$\tilde{\pi}_i(a, \mu) = \frac{1}{\varepsilon} \tilde{r}_i(a, \mu) - F;\ \tilde{\pi}_{i,x}(a, \mu) = \frac{1}{\varepsilon} \tilde{r}_{i,x}(a, \mu) - F_x \tag{7}$$

2.5. Decisions of Cross-Border e-Suppliers

Extending the basic framework of Melitz's [8] model, this study intends to use the free entry condition (FE condition) and the ZCP condition to obtain the minimum productivity level required to survive in the market, as well as to ensure the existence and uniqueness of the equilibrium. Referring to the description of equilibrium by Antras and Helpman [9] and Helpman *et al.* [10], the manufacturers' ZCP condition can be further expressed as follows:

$$\frac{1}{\varepsilon} R\left(\hat{P}\right)^{\varepsilon - 1} (1/\rho)^{1-\varepsilon} \varphi^{\varepsilon - 1} = F \Rightarrow ZCP\ condition$$

$$\frac{1}{\varepsilon} R_f\left(\tilde{P}_f\right)^{\varepsilon - 1} (\tau/\rho)^{1-\varepsilon} \varphi^{\varepsilon - 1} = F_x \Rightarrow Crossborder - ZCP\ condition$$

Using the above two equations, the combination of technical efficiency and demand index that satisfies ZCP condition (φ^*) and cross-border ZCP condition (φ_x^*) can be obtained. In addition, when $\varphi > \varphi^*$, the

manufacturers' operating profit is greater than zero; however, when $\varphi < \varphi^*$, the operating profit is less than zero. Furthermore, $\varphi > \varphi_x^*$ indicates that the manufacturer is able to serve consumers on cross-border e-commerce platforms and ensure that their cross-border operating profits exceed zero; otherwise, the manufacturer is not able to do so. Since manufacturers' productivity is affected by two variables (demand index and the technical efficiency), the ZCP condition and cross-border ZCP condition can be further expressed as follows:

$$\mu_i = \frac{p_\mu a_i^{\vartheta-1}}{\rho\hat{P}}\left[\frac{\varepsilon F}{R}\right]^{\frac{1}{\varepsilon-1}};\ \mu_{i,x} = \frac{\tau p_\mu a_{i,x}^{\vartheta-1}}{\rho\hat{P}_f}\left[\frac{\varepsilon F}{R_f}\right]^{\frac{1}{\varepsilon-1}};\ \varepsilon > 1 \tag{6}$$

Based on (6), the ZCP curve and cross-border ZCP curve could be obtained (see Fig. 1). As is shown in Figure 1, when manufacturers' operating profit from cross-border e-commerce platforms is zero, the likely combination of productivity (demand index and technical efficiency) can be divided into three regions. The region in the upper right corner, above the cross-border ZCP curve was defined as Region III. In this region, a combination of productivity closer to the upper-right corner indicates a higher operating profit and more capability of providing cross-border e-commerce services. It is worth mentioning that the combination of productivity is affected by the demand index and technical efficiency. Therefore, various combinations of the demand index and technical efficiency may lead to different levels of productivity. In addition, this conclusion can be observed with real market competition. In Fig. 1, technical efficiency was introduced as the vertical axis and the consumer demand index as the horizontal axis.

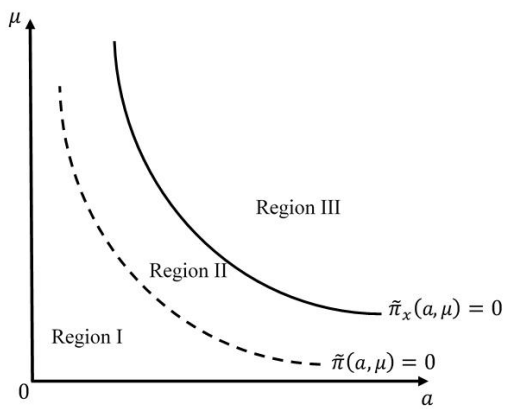

Fig. 1. ZCP and cross-border ZCP curves.

3. Asymmetric Demand Indices between Countries

This section examines how, when technical efficiencies are the same ($\mu_{i,x}^d = \mu_{i,x}^f$), the asymmetry in the demand index between the two countries ($a_{i,x}^f > a_{i,x}^d$) could affect manufacturers' (both at home and abroad) decision to provide a cross-border e-commerce service. Based on (6), the ZCP curve and cross-border ZCP curve can be further expressed as follows:

$$\mu_{i,x}^d = \frac{\tau p_\mu (a_{i,x}^f)^{\vartheta-1}}{\rho\hat{P}_f}\left[\frac{\varepsilon F}{R_f}\right]^{\frac{1}{\varepsilon-1}};\ \mu_{i,x}^f = \frac{\tau p_\mu (a_{i,x}^d)^{\vartheta-1}}{\rho\hat{P}_d}\left[\frac{\varepsilon F}{R_d}\right]^{\frac{1}{\varepsilon-1}} \tag{7}$$

where $a_{i,x}^f$ symbolizes the demand index generated by the network effect and information sharing obtained from foreign consumers through domestic cross-border e-commerce platforms; $a_{i,x}^d$ symbolizes

the demand index generated by the network effect and information sharing obtained from domestic consumers through foreign cross-border e-commerce platforms. Based on (7), it can be concluded that when foreign consumers have a stronger preference towards domestic products than domestic consumers owing to the usage of cross-border e-commerce platforms, the slope of the ZCP curve tends to be smoother; otherwise, the ZCP curve becomes steeper. (see Fig. 2). In Fig. 2, CBS refers to "providing cross-border service and non-CBS refers to "not providing cross-border service".

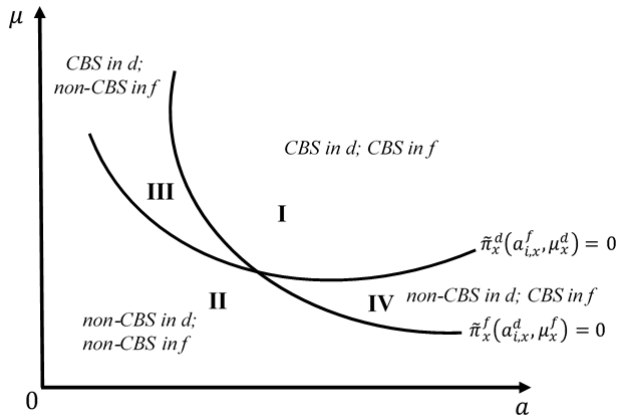

Fig. 2. When $\mu_{i,x}^d = \mu_{i,x}^f$ and $a_{i,x}^f > a_{i,x}^d$.

As is shown in Figure 2, the ZCP curve and cross-border ZCP curve divide all the likely combinations of technical efficiency and demand index into four regions: Manufacturers in Region I have the ability to serve cross-border consumers through both domestic and foreign cross-border e-commerce platforms. Manufacturers in Region II are not able to provide a service to cross-border consumers through domestic or foreign cross-border e-commerce platforms. However, in Region III and IV, the situations become more complex. Taking Region III as an example, the productivity combination of manufactures in this region is higher in technical efficiency and lower in the demand index. This combination is advantageous for domestic manufacturers when providing services to cross-border consumers through cross-border e-commerce platforms. Although foreign consumers' preferences towards a given product is low, due to an insufficient network effect and information sharing through cross-border e-commerce platforms, the productivity level is still skewed to the right of the domestic cross-border ZCP curve. In addition, a higher technical efficiency allows the manufacturer to be able to afford the cost of providing cross-border e-commerce. Therefore, these manufacturers are more inclined to provide cross-border e-commerce services to cross-border (foreign) consumers. However, in the case of foreign manufacturers with the same productivity combination, due to domestic consumers' lower demand for foreign cross-border e-commerce platforms, as well as the productivity level being on the left of the foreign cross-border ZCP curve, the manufacturers gain no advantage in providing cross-border e-commerce services to cross-border (domestic) consumers. Due to the limited length of the article, the descriptions of the decisions of Region IV manufactures were omitted. The results of the study showed that, when two countries have the same level of technical efficiency, the network effect and information sharing generated by their cross-border e-commerce platforms could affect consumer demand. Cross-border e-commerce platforms that engender greater confidence among cross-border consumers could help manufacturers to export more products and obtain a higher profit. On that account, the development and improvement of a country's cross-border e-commerce platforms is likely to have a positive impact on the export earnings of its manufacturers.

4. Conclusions

This study analyzed the impact of network effect, information sharing, and feedback obtained from consumers through cross-border e-commerce platforms on manufactures' decisions to provide corresponding services. The purpose was to further analyze manufacturers' productivity and decision-making processes when presented with changes in consumer demand caused by e-commerce platforms. By extending the framework of the model proposed by Melitz (2003), two variables (technical efficiency and demand index) were included as heterogeneous characteristics of the manufacturers. It was found that the area of likely combination of productivity was divided into three regions by the ZCP curve and cross-border ZCP curve. In addition, a combination of productivity levels closer to the upper-right corner indicates that the company is more capable of providing cross-border e-commerce services, while a combination of productivity levels closer to the lower-left corner indicates that the company is less capable of providing cross-border e-commerce services. Furthermore, if the consumer demand index of a given cross-border e-commerce platform varies between two countries, the combined area of technical efficiency and demand index could be divided by the cross-border ZCP curve into four regions. When cross-border technical efficiency remains unchanged, the country with the better cross-border e-commerce platform is more likely to generate a network effect and increase information sharing from cross-border consumers. The findings of the study serve as a reference for manufacturers to increase their export of products and obtain higher profits, besides providing theoretical support and motives for governments and enterprises to improve cross-border e-commerce platforms. In recent years, China has witnessed rapid development of cross-border e-commerce and the Internet plus era with the active support of the government. Simultaneously, under the Belt and Road (B&R) Initiative, China has actively established close economic and trade relations with developing countries along the route. It is an important way for the realization of common development goals of the Belt and Road through the integration and development of the urban agglomerations in the Guangdong-Hong Kong-Macao Greater Bay Area. The conclusion of this article provides policy suggestions for the development and deepening of the Belt and Road Initiative and the Greater Bay Area. Through the joint development of China and the countries along the Belt and Road on bilateral cross-border e-commerce platforms, it will help bilateral manufacturers reduce costs and increase profits, and further help to build closer and favorable economic and trade relations.

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