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Market size, productivity and product quality regarding firm heterogeneity

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ABSTRACT

The importance of market scale really affects a set of economic orientations in real world, such as economic structure, trade patterns, competitive behaviours of firms, and decisions of government policies and enterprises, etc. Simultaneously, considering the production efficiency and product quality as the productivity calculation of one firm, our expanded model tries to answer how does the market scale of the world affect the operation and survival of enterprises and how does the asymmetrical market scales derive the changes of firms' exporting decisions. Our article gets the following two results. When the global market expands, we find that those combinations of production efficiency and product quality originally unable to serve the domestic market or be exported are turned to meet domestic or export demand. Next, the effect of the asymmetric scale between two countries' markets would derive the four areas which describe different export decisions under various production efficiency–product quality combinations. This explains that reasonable combinations of production efficiency and product quality will be the critical point to export.

1. Introduction

The scale of a country's market affects its market structure, economies of scale, government policy decisions, trade patterns, firms' pricing and costs, competitive behaviour, and location selection. The importance of market scale is also visible in the frameworks of new trade theories. Krugman (1980), for example, discusses on trade patterns; in this model, increasing returns to scale and transportation costs play important roles. A country with a relatively large market scale attracts firms to enter industries that exhibit increasing returns to scale, while the large market effect that results in reduced production and transportation costs causes the country to become a net exporter. This effect also influences firms' decisions about their production locations.

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Based on the foregoing, the present study addresses several elements of this topic: product quality, and productivity heterogeneity; these elements are considered jointly with market scale herein. This is important because although recent studies have gradually begun to emphasize the effects of market scale on firms' productivity and product quality, relatively few such studies are available. The differences in product quality and production efficiency can affect firms' profits and that these two variables can also interact with one another, implying that under conditions of fixed profits, if a firm chooses to produce a lower-quality product, it must improve its production efficiency to maintain the same level of profits, and vice versa. As such, if we consider the effect of only one variable in our discussion, our results and strategy selections may differ from real-world conditions. On this basis, this study attempts to explain the effects of asymmetric market scale or increases in the scale of entire markets on the survivals and operations of firms under conditions of product quality and productivity heterogeneity in addition to topics related to firms' export productivity and export decision.

In this study, firms' productivity is defined differently to in the past literature. In particular, it is measured by using variables for production efficiency and product quality. As such, under the assumption of fixed productivity, high productivity may be the result of three scenarios: high production efficiency and high product quality, high production efficiency and low product quality, or low production efficiency and high product quality. For this definition of productivity, under a market scale and monopolistic competition framework, we explore the effects of an increase in the scale of the global market and of asymmetric scale between the national markets. This study finds that for both the home and the foreign market, an increase in the scale of the global market permits firms with lower productivity to survive; this means that the number of firms and product types in a market will increase, but overall average productivity will decline. Similarly, for export decisions, the number of domestic and foreign firms capable of exporting and the number of product types will increase, whereas overall average export productivity will decline. Given the asymmetric scale between the two countries' markets, when the market of the home country is larger, the home market will permit firms with lower productivity to survive, causing an increase in the number of producers and product types and a decline in overall average productivity. By contrast, when the foreign market is smaller, the result is the opposite of that described above. With regard to export decision making, the number of home country firms capable of exporting will decline, meaning that firms with higher productivity will be better able to export. The reason for this is that when the foreign market is small, average productivity increases, and thus domestic exporting firms need to have higher productivity to remain competitive.

In addition, this study finds that given the asymmetric markets in the two countries, by using a zero-profit curve for exports, where heterogeneous firms in the two countries have different production efficiency–product quality combinations, firms' export decisions can be divided into four areas on this curve. These four areas describe the export decisions of the home country and foreign country for different production efficiency–product quality combinations. These also explain that the firms which only with high production efficiency (accompanied by low product quality) or

high product (accompanied by low production efficiency) quality may still not to meet the threshold for exports; rather, it is necessary to simultaneously have a quite level of product quality and production efficiency to meet the export threshold, and these circumstances are easier to happen as each country's market becomes more asymmetric in scale.

The layout of the subsequent sections of this paper is as follows. The second section is literature review. In the third section, we present a theoretical framework that addresses consumers' preferences, firms' production, and the equilibrium outcomes. The fourth section is more analytical; here, we discuss the various effects caused by the expansion of the global market as well as the asymmetric market scale of the two countries. In the fifth section, we present our conclusions.

2. Literature review

Literature collected for this study discusses the interactions between production efficiency, product quality and market size. First, the product quality affects the utility of consumers. Consumers prefer to consume high-quality products, and where product quality is higher, so too is utility, and vice versa. With regard to the supply side, firms respond to consumer demand for product quality and set prices with a view to maximizing profit. Where they choose to produce higher-quality products, their prices will be higher; moreover, when consumers choose to consume a product of higher quality, their utility will also be higher, but they must also pay a higher price; this results in a substitution relationship between price and quality. Thus, the product quality variable is crucial for understanding consumers' utility and firms' profits.

Shaked and Sutton (1987) propose that in an industry where product quality costs are fixed, when the market increases in scale, this will cause at least one firm to actively invest in product quality, meaning that product quality will increase with increases in market scale in some industries. However, if product quality costs are variable, Berry and Waldfogel (2003) state that larger market scale can result in market segmentation and the provision of a broader range of products. Furthermore, Han and Chouinard (2014) simultaneously consider market scale, product quality, and advertising intensity. Their results show that as market scale increases and firms rise in number, firms' advertising intensity declines; moreover, when more firms enter the market, their choice of product quality initially increases and then gradually declines. Picard (2013) considers firms' product quality decisions in a competitive monopolistic market, showing that countries with larger market scale produce high-quality product types and that the difference in quality becomes greater as the scale of the two regions' markets becomes increasingly incongruous. Furthermore, higher trade costs result in an increased disparity in the product quality of the two regions. Recent researches have also raised some viewpoints. Gervais (2015) uses the data of U.S. manufacturing plants to separate contributions of product quality and technical efficiency in explaining the variations of export outcomes. This article finds that the idiosyncratic demand is consistent with the quality interpretation and which will further affect the decisions of the export and the levels of foreign sales. It implies that special demands of consumers for products also derive the heterogeneities of firms

and the variations of export outcomes. Antoniades (2015) presents a trade model of heterogeneous firms, endogenous quality choice, and endogenous markups to observe the competition behaviours between different firms. The critical results indicate that the most productive firms do the ways of rising quality, prices, and markups to face the competition, while the least productive firms take the opposite of ways. Moreover, Auer et al. (2018) considers a model in which the consumers own different marginal willingness to pay for quality increments by the heterogeneous income. Compared to low qualities, the relative price of high qualities increases with the income of the destination market. It implies that the heterogeneous preference of consumers for quality is exhibited by the heterogeneous income among the countries. Bonfiglioli et al. (2018) uses a simple theoretical framework and transaction-level U.S. import data to find that the scale of firm-products explains half of the variation in sales, while the other half comes from the average attributes and their dispersion. It implies that the quality plays a critical role for determining the firm heterogeneity. In summary, most past studies discuss the effects of market size on product quality decisions given the similarity between firms' production efficiency. They have not simultaneously considered the effects of the variation in production efficiency, market scale, and quality selection on firms' decision making. But the recent studies start to consider these factors simultaneously, and their results may differ from those under conditions where only considers the factors of market size and product quality.

Secondary, the characterization of a firm's productivity is described by the labour inputs required for each unit of production; when each unit of production requires less labour input, the firm has higher productivity, and vice versa. This situation also illustrates that productivity is negatively correlated with labour inputs. Early definitions of firms' productivity generally assumed productivity homogeneity. Krugman (1980) analyzes the framework of firms' productivity homogeneity under conditions of monopolistic competition and argues that under these conditions all firms set the same prices and have zero long-run profits. He also observes that when market scale increases, the number of firms rises, as does social welfare.

After that, the studies' definitions of productivity have gradually shifted to a framework of productivity heterogeneity. For instance, by using a monopolistic competition market framework, Melitz (2003) takes productivity heterogeneity into account to further analyze trade outcomes within an industry. His principal results illustrate that firms with higher productivity are better able to simultaneously supply products for domestic and foreign markets. Subsequently, Melitz and Ottaviano (2008) state that market size affects the intensity of market competition as well as the selection of export strategies by heterogeneous firms.

In a study of economic agglomeration, Baldwin and Okubo (2006) note that firms with high productivity are more attracted by large markets to engage in agglomeration, as they have lower marginal costs and can sell more products in large markets, thereby encouraging the agglomeration of high productivity firms. This finding implies that firms with higher productivity are more able to compete in large markets and suffer smaller losses, which causes firms' decisions to migrate from small markets to large markets to be affected by their productivity heterogeneity. The recent studies, Foellmi and Zweimüller (2017) indicates that the inequality which involved a price

effect and a market size effect would affect the incentive of innovation. An innovator who has a large productivity advantage over than a traditional producer, a higher level of inequality will derive the innovator to charge a higher level of price and mark-up. It also implies that the inequality which is from the market size may influence the producers' decisions of behaviours. Ramondo et al. (2016) presents that the scale effects derive the import shares decrease and relative income levels increase speedily with country size. Based on a critical assumption, the results of model are largely consistence with the data. Ding and Niu (2018) uses the firm-level data on Chinese manufacturing industries for the period 1998–2007 to investigate the selection effects of market size on firm productivity. This paper finds that the market size tends to derive greater selection effects of productivity in such industries with stronger local protections, scale economies or product differentiation. It also implies that the market size may drive the changes of productivity in sectors. In addition, Yang and Tsou (2018) and Chen (2019) also present their viewpoints for productivity of exporting firms. Chen (2019) indicates that when an economy opens to trade but facing a decline of market size in the open economy, managers of surviving firms with least productivity level are incentivized to do more effort and which will derive the productivity rising. The results of this article implies that exists some factors may directly or indirectly influence a firm's productivity. Hence, although market size is closely related to firms' productivity, studies have not considered the effects of critical variables such as product quality on consumer utility and producer profit; the inclusion of these variables may result in different outcomes.

Recently, a few articles with production efficiency and product quality support our viewpoints indirectly. Jiang and Yang (2018) uses a dynamic, game-theoretic model to find out that when a firm's high efficiency is public and well known, the firm may adopt the strategy of decline of product quality. It means that a firm may use a way of high efficiency and low product quality to compete with its rivals at some specific situations. Moreover, Aw and Lee (2017) uses the firm heterogeneity which are distinguished by quality and productivity to examine the export performance of Taiwanese multiproduct firms. The cost elasticities of quality improvement are used to determine the relative importance of degree of firm heterogeneity. The empirical results of this paper find that both quality and productivity play critical roles to determine the firm export participation and export scope. Quality has more parts of contributions on export decisions for firm in more heterogeneous product markets and products with lower cost elasticities of quality improvements, while productivity is more importance in markets with low degrees of product differentiation but high cost elasticities of quality improvements. The results of Aw and Lee (2017) indirectly support our investigation that the different combinations of production efficiency and product quality can influence the export decisions of heterogeneous firms.

More specifically, the production efficiency and product quality should be better to assess the productivity. Thus, the settings of model in this paper relies on the monopolistic competition market framework in Melitz (2003) and Aw and Lee (2014). Based on above to analysis the firms' behaviours and export decisions in the expansion of the global market and the asymmetric market scale of the two countries.

3. Theoretical framework

This study extends the basic framework established by Melitz (2003). Within our definition of heterogeneity, we include two variables: production efficiency and product quality. This definition is similar to that proposed by Hallak and Sivadasan (2009), where production efficiency and product quality are randomly drawn from a combined probability distribution and simultaneously affect firms' profits. Furthermore, consumers can further influence demand for some types of products through their preference for different quality levels as well as change firms' pricing strategies. We explain this in detail in the following subsections.

3.1. Preferences

To discuss the effects of an asymmetric market scale between countries or of overall market expansion, this study assumes that the scale of the global market is L, where γL $(0 < \gamma < 1)$ describes the market of the home country and $(1 - \gamma)L$ describes the foreign market. In each period, each consumer has a one-unit labour endowment. Furthermore, we assume that consumers have no preference for leisure and that their supply of labor to the market is inelastic. Consumers' utility is derived from the consumption of different products, as described by the following equation:

$$U = \left\{ \int_{i \in I} \left[\omega(i)q(i) \right]^{\rho} di \right\}^{\frac{1}{\rho}}, \; \rho \in (0, 1) \tag{1}$$

where $\omega(i) \geq 1$ indicates product quality, $q(i)$ the number of units of product i consumed, and I all possible product type combinations. Product quality is used to indicate the characteristics of each product type and increase the demand conditions for the product price. This means that as the product price increases, consumers' utility also rises; however, a higher price must be paid for the product, and vice versa. Furthermore, $\tilde{q}(i) \equiv \omega(i)q(i)$ is defined as quality-adjusted quantity after adjusting for product quality. This refers to the amount of this product type consumed by consumers, where product types have specific product quality characteristics. We further assume that the elasticity of substitution between product types is a fixed value, ε $(\varepsilon \geq 1)$, where $\varepsilon = 1/(1-\rho)$.

We also consider the budget constraint for maximizing consumers' utility: $\int_{i \in I} p(i)q(i)di = R$. We can deduce the demand function for product category i as follows:

$$\tilde{q}(i) = R \tilde{P}^{\varepsilon - 1} \left(\tilde{p}(i) \right)^{-\varepsilon} \tag{2}$$

where R refers to expenditure for the entire industry. In the home country, $R_d = w(\gamma L)$ expresses total national income from labor, where the nominal wage is set to $w = 1$. Foreign income from labor is defined as $R_f = w[(1-\gamma)L]$. Furthermore, $\tilde{p}(i) \equiv p(i)/\omega(i)$ is defined as the quality-adjusted price for a product type and $\tilde{P} = [\int_{i \in I} \left[p(i)/\omega(i) \right]^{1-\varepsilon} di]^{\frac{1}{1-\varepsilon}}$ refers to the integrated quality-adjusted price index for the entire industry.

3.2. Production

In this study, we extend the basic definitions of production presented by Krugman (1980) and Melitz (2003), which state that labour is the only input into the production process. Total production costs are calculated by using the production volume, marginal cost of each unit, and fixed overhead costs. Product quality and production efficiency affect the marginal cost. On this basis, we define production efficiency for each unit of output as $\theta \in (1, \infty)$; under the precondition of standardized nominal wages, $w = 1$, our total cost function is presented as follows:

$$TC(i) = f + \frac{\omega(i)^{\eta}}{\theta(i)} \; q(i) \tag{3}$$

where f is the fixed overhead cost. A positive (negative) correlation between the marginal cost and product quality (production efficiency) is also implied, meaning that firms' costs increase and production efficiency decreases as product quality increases. We can see that these two variables have an interactive relationship with firms' profits. Furthermore, η is a fixed value representing the production cost elasticity; this study assumes that the domestic and foreign production cost elasticities are equal. In addition, when this fixed value increases, it raises firms' production costs.

3.3. International trade

For international trade, this study assumes that the world is composed of two countries: the home country and foreign country. Furthermore, when firm exports products to the foreign country, it must pay tariff and transportation costs. In addition, firms capable of exporting must also pay fixed export costs to enter the export market; these costs are defined as f_x. Transportation costs are defined according to an iceberg cost model, where $\tau \geq 1$; hence, when exporting τ product units, only one unit reaches the foreign market. The above costs are established given that the product quality conditions are the same for all firms.

3.4. Profit maximization

The problems faced by heterogeneous firms can be described in the following steps. In the first step, all potential firms face a fixed entry cost and forecast their potential future profits. They then compare this with their current fixed entry costs; where their forecasted profits are larger than or equal to the entry costs, they choose to enter the market. In the second step, firms enter the market and randomly draw their product quality and production efficiency combination from a joint probability distribution, $g(\omega, \theta)$. For all firms who draw a product quality–production efficiency combination, they simultaneously decide whether to remain in the domestic market or export to the foreign market as well as their pricing for the domestic and foreign markets. At this time, firms face two fixed costs: fixed overhead costs and fixed export costs. Taking into account product quality and production efficiency, the maximization problem for firms' profits is expressed below:

Table 1. Equilibrium results.

$\varphi^* \le \varphi < \varphi_x^*$	$\varphi_x^* \le \varphi < \infty$
$p(i) = \omega(i)^\eta / \rho\theta(i)$	$p_x(i) = \tau\omega(i)^\eta / \rho\theta(i)$
$q(i) = \gamma L\left(\tilde{P}_d\right)^{\varepsilon-1} \omega(i)^{\varepsilon-1} p(i)^{-\varepsilon}$	$q_x(i) = (1-\gamma)L\left(\tilde{P}_f\right)^{\varepsilon-1} \omega(i)^{\varepsilon-1} p_x(i)^{-\varepsilon}$
$r(\omega,\theta) = \gamma L\left(\tilde{P}_d\right)^{\varepsilon-1}[\omega(i)^{\eta-1}/\rho\theta(i)]^{1-\varepsilon}$	$r_x(\omega,\theta) = (1-\gamma)L\left(\tilde{P}_f\right)^{\varepsilon-1}[\tau\omega(i)^{\eta-1}/\rho\theta(i)]^{1-\varepsilon}$
$\tilde{\pi}(\omega,\theta) = \frac{1}{\varepsilon}r(\omega,\theta) - f$	$\tilde{\pi}_x(\omega,\theta) = \frac{1}{\varepsilon}r_x(\omega,\theta) - f_x$

Source: Manipulations by the author.

$$\max_{p(i),\, p_x(i),\, \Gamma_x} \pi_i(\omega,\theta) = \left[\left(p(i) - \frac{\omega(i)^\eta}{\theta(i)}\right)q(i) - f\right]$$

$$+ \Gamma_x\left[\left(p_x(i) - \frac{\tau\omega(i)^\eta}{\theta(i)}\right)q_x(i) - f_x\right] \tag{4}$$

In the above equation, when $\Gamma_x = 1$, the firm simultaneously supplies products to both the domestic and the foreign markets. By contrast, when $\Gamma_x = 0$, the firm only supplies products to the domestic market. $p(i)$ and $p_x(i)$ represent the price of a product type in the domestic market and export market, respectively. $q(i)$ and $q_x(i)$ represent the optimal demand for each product type. The optimal prices are chosen according to the following equation:

$$p(i) = \frac{\omega(i)^\eta}{\rho\theta(i)}; \quad p_x(i) = \frac{\tau\omega(i)^\eta}{\rho\theta(i)} \tag{5}$$

The above equation shows that the optimal price will increase as product quality increases; however, as production efficiency decreases, the optimal price will decline, resulting in mutually different influences on the optimal pricing. Furthermore, based on the framework for preferences established in this study, the firm's markup is a fixed value, $1/\rho$, indicating that the exclusivity of its product type is the same and those firms earn positive profits.

3.5. Analysis of the equilibrium

This study extends the basic framework established by Melitz (2003). By using the free entry condition[1] and zero-cut off condition,[2] we derive the minimum productivity level necessary for a firm to survive in the market and ensure that there is a single equilibrium.[3] Table 1 presents the equilibrium conditions for firms only capable of supplying the domestic market and those capable of exporting.[4]

By extending the description of the equilibrium provided by Helpman, Melitz, and Yeaple (2004) and Antràs and Helpman (2003), we further amend the zero-cut off condition and export-zero-cutoff condition as follows:

$$\frac{1}{\varepsilon}\gamma L\left(\tilde{P}_d\right)^{\varepsilon-1}(1/\rho)^{1-\varepsilon}\varphi^{\varepsilon-1} = f \Rightarrow ZCP\ condition$$
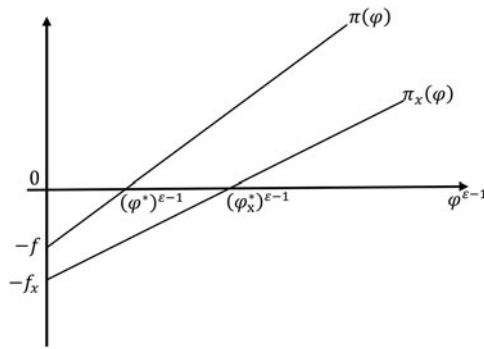
**Figure 1.** Firms' profits and threshold values. Source: Manipulations by the author.

$$\frac{1}{\varepsilon}(1-\gamma)L\left(\tilde{P}_f\right)^{\varepsilon-1}(\tau/\rho)^{1-\varepsilon}\varphi^{\varepsilon-1} = f_x \Rightarrow Export - ZCP\ condition$$

In Figure 1, $\varphi^{\varepsilon-1}$ indicates the equilibrium described by the horizontal axis that determines firms' profit, where $\pi(0) = -f$. Herein, $-f_x < -f$ describes that firms capable of exporting need to pay a fixed export cost to export and that this export cost is typically larger than the fixed overhead costs. When the two national markets are symmetric, $\gamma L = (1-\gamma)L$ and $\tilde{P}_d = \tilde{P}_f$. Hence, the slope of the profit curve for firms capable of supplying to the domestic market is greater than that of firms capable of exporting. This result is caused by the effects of transportation costs and product substitution elasticity ($\tau^{1-\varepsilon}$).

Furthermore, the fluctuations in firms' profits are caused by the effects of production efficiency and product quality. The export-zero-cutoff condition is adjusted according to these variables to attain an equal-zero-profit curve[5] for when the production efficiency–product quality combination yields zero profits. This is expressed below:

$$\theta_x(i) = \frac{\tau\omega(i)^{\eta-1}}{\rho\tilde{P}_f}\left[\frac{\varepsilon f_x}{(1-\gamma)L}\right]^{\frac{1}{\varepsilon-1}},\ \varepsilon > 1 \tag{6}$$

Figure 2 shows that on the zero-cutoff curve, there is a substitution relationship between production efficiency and product quality. Hence, under the precondition of fixed profits, an unlimited number of production efficiency–product quality combinations are capable of satisfying the zero-cutoff condition. Figure 2 also shows that at the bottom left of the isoprofit curve when export profits are zero, as we move towards the bottom left, the export profit is smaller. This means that in this area of the curve, no production efficiency–product quality combinations allow a firm to export. By contrast, at the top right of the equal-zero-profit curve, as the firm moves further to the upper right, it becomes easier to export. Further, to the bottom left of the equal-zero-profit curve, there is also a home country equal-zero-profit curve (as shown in Figure 2). Moreover, for the production efficiency–product quality combinations at the bottom left of the curve, it is impossible to simultaneously meet domestic and export demand.
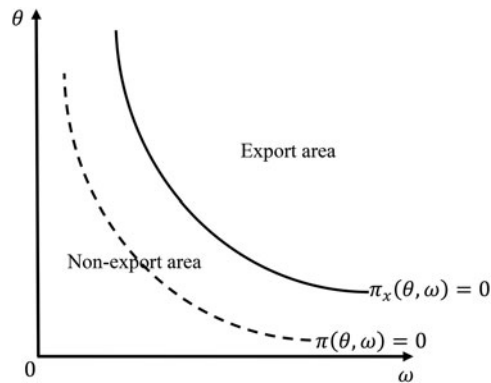
Figure 2. Export and non-export areas. Source: Manipulations by the author.

4. Comparative analysis

This section primarily discusses the extent to which the scalar expansion of the global market or the scalar asymmetry between national markets affects the variation in average national productivity. Here, we consider the effects on productivity in the home market, export productivity, and export decision making. To understand the changes caused by fluctuations in market scale, in our basic model, we define the scale of the global market as L, where γL $(0 < \gamma < 1)$ describes the home country market and $(1 - \gamma)L$ describes the foreign country market. An increase in the scale of the global market indicates that, all other conditions remaining the same, L increases. The asymmetry between national markets indicates the effects caused when the scale of the global market remains the same and the scale of each country's market as a proportion of the global market is unequal: γ for the home country and $(1-\gamma)$ for the foreign country. In the following subsections, we describe the situations where the global market expands and national markets have asymmetric scale.

4.1. The case of the global market scale expanding

For analyzing the effects of the global market expansion, our article firstly assumes that the scale of the two national markets is equal, such that $\gamma = (1-\gamma)$. Under this precondition, the exogenous variable L expands, $(L \rightarrow L')$, and we analyze the profits of firms only capable of supplying the domestic market and those capable of exporting (Table 1). We can see that the slope of the profit function for firms only capable of supplying the domestic market increases, while the slope of the profit function for firms capable of exporting remains the same.[6] Figure 3 describes the effect of the scalar expansion of the global market on the productivity thresholds. When the scale of the global market increases, it permits firms with lower productivity to serve the domestic market; similarly, the threshold for exporting firms also decreases. Furthermore, by reducing the productivity thresholds for the domestic and export markets,[7] overall average productivity and overall average export productivity simultaneously decrease. In addition, demand for specific types of products will increase as the scale of the global market increases, although pricing will be unaffected and the
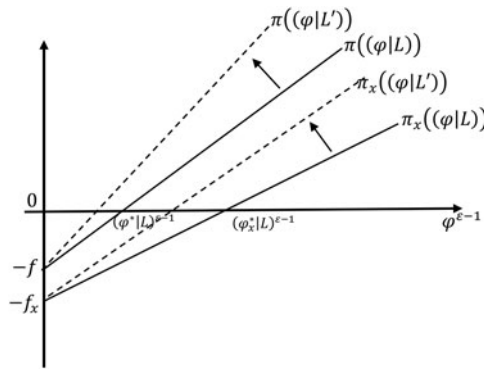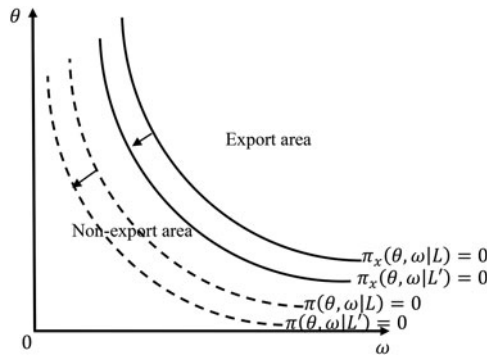
Figure 3. Changes in the threshold values for an expansion of global market scale. Source: Manipulations by the author.

profits of individual firms will increase. Figure 4 describes that as the scale of the global economy increases, the home country's equal-zero-profit curve and export equal-zero-profit curve both shift to the bottom left. Taking the case of exports, this finding indicates that when the scale of the global economy increases, it permits combinations of production efficiency and product quality that were originally unable to export to meet export demand. Figure 4 illustrates that the area of the curve capable of exporting has increased; similarly, the production efficiency–product quality combinations capable of supplying the domestic market have also increased, meaning that the number of firms in the industry will increase.

4.2. The case of the asymmetric market scale between the countries

In this subsection, we discuss the effects of asymmetric market scale between the two national markets. To simplify the analysis, we establish that the scale of the global market is fixed, L, and that the asymmetric scale between the national markets comes from the shares of the global market occupied by each. Specifically, the scale of the home market is $\gamma_d \equiv \gamma$, while that of the foreign market is $\gamma_f \equiv (1-\gamma)$. Considering the changes in the home country market in Table 1, when the scale of the home country market increases ($\gamma \uparrow$), we find that the slope of the profit function increases for firms only capable of supplying the domestic market, whereas the slope of the profit function for firms capable of exporting decreases. By contrast, when the scale of the foreign market declines, the changes in slope and home market conditions are reversed.[8] Figure 5 takes the case of the home country to explain the above circumstances. When the scale of the home country market increases, this allows firms with lower productivity to survive in the home market, although the productivity threshold for exporting firms increases. These finding shows that the home country's exporting firms must have higher productivity to export to the foreign market, because as the scale of the foreign market decreases, overall average productivity increases and productivity competition is more intense for domestic exporting firms. By contrast, the results for the foreign market are the opposite. For firms in the foreign market, productivity must be higher to survive because the scale of the foreign market has decreased, meaning that firms require higher productivity to survive in the market. However, because foreign exporting firms experience increased demand from the

Figure 4. Changes in the equal-zero-profit curves for the expansion of global market scale. Source: Manipulations by the author.
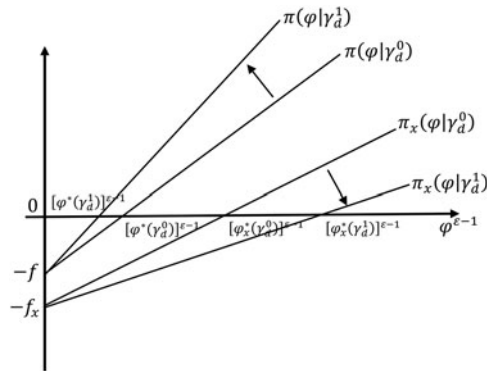
Figure 5. Changes in the threshold values for the expansion of home market scale ($\gamma_d^1 > \gamma_d^0$). Source: Manipulations by the author.

home market, the productivity threshold for exporting to the home market is lowered. Furthermore, for home country consumers, as the scale of the home market increases, they can consume more product types and a greater variety of product quality, while the opposite is true for foreign consumers.

Furthermore, when the scale of the two countries' markets is asymmetric, taking the case where the scale of the home country market is larger than that of the foreign country market, this study finds the following. Given the production efficiency–product quality combination, the slope of the equal-zero-profit curve for the home country is smaller than that of the foreign country. Similarly, the same relationship exists between the equal-zero-profit curves for the home and foreign countries, as described in Figure 6. Taking the case of export decision making for the two countries' firms, the export equal-zero-profit curves for the home country and foreign country firms can divide export decision making into four areas: area 1, where the home country exports to the foreign country and the foreign country exports to the home country; area 2, where the home country does not export to the foreign country and the foreign country does not export to the home country; area 3, where the home country exports to the foreign country but the foreign country does not export to the home country; and area 4, where the home country does not export to the foreign country but the foreign country does export to the home country. In area 1, firms have high
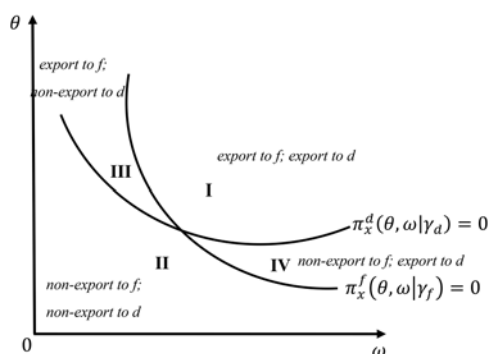
Figure 6. Export decision making. Source: Manipulations by the author.

production efficiency and product quality, and so both home country and foreign country firms are capable of exporting. By contrast, in area 2, firms have low production efficiency and low product quality, and so neither of the country's firms is capable of exporting. However, in area 3, where both countries have similar production efficiency and product quality combinations, the home country's firms can export to the foreign country, while the foreign country's firms cannot export to the home country. This is because of the expanded demand for the home country market, which allows for a decrease in the productivity threshold for foreign country-exporting firms, although the foreign firms who meet this productivity combination threshold are unable to pay the fixed export costs, meaning that they would suffer a loss if they chose to export. By contrast, in area 4, for a fixed combination of production efficiency and product quality, home country firms are incapable of exporting to the foreign country, but foreign country firms can export to the home country; the reason that home country firms cannot export is that the scale of the foreign market is small and the average productivity of foreign firms is higher than that of home country firms, meaning that they require higher productivity to export. Hence, home country firms with productivity combinations in this area cannot meet all the export requirements and so cannot export. Finally, from our discussion of firms' decision making on exports based on Figure 6, firms with high production efficiency and low product quality or low production efficiency and high product quality are not capable of meeting the export conditions. As the scale of the two countries' markets becomes more asymmetric, this situation occurs more readily.

5. Conclusion

Reviewing the literature on product quality and production efficiency illustrates their possible interactive effects, which further affect firms' profits. To describe this scenario, this study extended the basic framework proposed by Melitz (2003) by including production efficiency and product quality as variables. To measure productivity, it simultaneously considered product quality–production efficiency combinations such that $\varphi(\omega, \theta) = \theta \omega^{1-\eta}$. This measurement method implies a given level of productivity, yielding an unlimited number of production efficiency–product quality combinations capable of satisfying these conditions. Furthermore, although many recent studies simultaneously examine product quality and production efficiency, few have

discussed the multiple effects on firms caused by an asymmetric scale between national markets or an expansion in the overall scale of the global market.

When the scale of the global market increases, on the precondition that outcomes are unaffected, we establish two national markets of equal scale, such that the outcomes for each are the same. Then, by taking the case of the home country, we find that the market allows for firms with lower productivity to supply the home market. Similarly, productivity for exporting firms also decreases. Furthermore, after changes in the domestic market and export productivity thresholds, overall average productivity and average export productivity simultaneously decline. However, demand for some product types will increase as the scale of the global market rises without affecting pricing, increasing the profits of some firms in the industry. In addition, the equal-zero-profit curves for the home and export markets show that when the scale of the global market increases, these two curves will simultaneously shift to the bottom left. Taking the case of the export market, this shift indicates that when the scale of the global market increases, the product quality–production efficiency combinations originally unable to supply the export market become capable of doing so.

Next, we discuss the effects of the asymmetric scale between the two countries' markets. Given the precondition that the scale of the global economy is fixed, when the home country market increases in scale, firms with low productivity can survive in the home market; however, the productivity threshold for exporting firms increases, indicating that exporting firms in the home country must have higher production capacity to be capable of exporting to the foreign country. By comparison, when the scale of the foreign country market decreases, we obtain the opposite result. Furthermore, as the scale of the home country market increases, the number of product types and variety of product quality that can be consumed both increase; this result is the opposite for foreign country consumers. Moreover, taking the case of export decision making for both countries, the export equal-zero-profit curves for both home country and foreign country firms divide export decision making into four areas. These four areas describe the different export decisions for the different combinations of production efficiency and product quality for each country's firms. These also explain that the firms which only with high production efficiency (accompanied by low product quality) or high product (accompanied by low production efficiency) quality may still not to meet the threshold for exports. Hence, the above circumstances would occur easier as each country's market becomes more asymmetric in scale.

In summary, the contribution of our article is that a firm's productivity is determined by production efficiency and product quality. The production efficiency comes from a firm's technical level and R&D inputs, but the decisions of product quality may directly (or indirectly) affected by the preferences of consumers in demand side. Hence, the production efficiency and product quality should be better to assess the productivity. Based on above settings, our article further investigates that the global market expands and the asymmetrical market scales how to affect the survivals and operations of firms and even the export decisions. The main results are different with the past literatures which only separately consider the relative issues of production efficiency and product quality. Hence, the

recommendations of our article can be summarized into two aspects. For the aspect of global market expands, it helps the survival and operation of manufacturers, otherwise they need more technical input and quality improvement to face more intense competition. For the aspect of asymmetrical market scales, our article suggests that the export firms of relative large market scale need a higher level of productivity to meet the export condition. Moreover, manufacturers that only focus on production efficiency or product quality will not be able to meet the export threshold. Reasonable combinations of production efficiency and product quality will be the critical point to export.

Finally, there are some issues that can be provided for further studies. First, the empirical analysis is the current limit of our article and which would be a critical work at the next investigation. Second, the preference of product quality of our manuscript is consistent in both countries. It is significantly different with the observations of real world. Hence, further relaxes this assumption will help the future studies. Moreover, such as Aw and Lee (2017), the cost elasticities of quality improvement play a critical role for determining the relative importance of degree of firm heterogeneity. Hence, the considering of difference in cost elasticities of quality improvement will contribute us to create more interesting issues. Last, the different productivity determination which is used on the same issue of our article will help to clarify the essence of the problem.

Notes

1. The free entry condition is expressed as $\tilde{\pi} = \frac{\delta f_e}{1 - G(\omega^*, \theta^*)}$, $\tilde{\pi} = \tilde{\pi}_d + \Gamma_x \tilde{\pi}_x$. Herein, the combination (ω^*, θ^*) is assumed to be the combination of product quality and production efficiency giving the firm a profit of zero.
2. The zero-cutoff condition is expressed as $\tilde{\pi} = f\left[\left(\frac{\tilde{\varphi}(\omega^*, \theta^*)}{\varphi^*(\omega^*, \theta^*)}\right)^{\varepsilon-1} - 1\right] + \Gamma_x prob.$ $(x) f_x \left[\left(\frac{\tilde{\varphi}_x(\omega^*, \theta^*)}{\varphi_x^*(\omega^*, \theta^*)}\right)^{\varepsilon-1} - 1\right]$, where φ^* and φ_x^* represent the zero-profit production efficiency threshold and zero-profit export production efficiency threshold, respectively. $\tilde{\varphi}$ and $\tilde{\varphi}_x$ represent average production efficiency and average export production efficiency, respectively. Furthermore, $prob.(x) = \left[1 - G(\varphi_x^*)/1 - G(\varphi^*)\right]$ represents the prior probability of firms successfully achieving export conditions.
3. See Melitz (2003).
4. The profits of export-capable firms come from servicing the home and foreign country markets.
5. The isoprofit curve when export profits are zero also satisfies $\frac{\partial \theta_x(i)}{\partial \omega_x(i)} = A(\eta-1)(\omega_x(i))^{\eta-2} < 0$, $\frac{\partial^2 \theta_x(i)}{\partial \omega_x(i)^2} = A(\eta-1)(\eta-2)(\omega_x(i))^{\eta-3} > 0$, $A \equiv \frac{\tau}{\rho P_f}\left[\frac{\varepsilon f_x}{(1-\gamma)L}\right]^{\frac{1}{\varepsilon-1}}$; this means that the curve is convex to the origin.
6. On the basis of this definition, the slope of the profit curve for firms only capable of supplying the domestic market is B; this means that $B \equiv \frac{1}{\varepsilon}\gamma L\left(\tilde{P}_d\right)^{\varepsilon-1}(1/\rho)^{1-\varepsilon}$; similarly, the slope of the profit curve for firms capable of exporting is B', meaning that $B'' \equiv \frac{1}{\varepsilon}(1-\gamma)L\left(\tilde{P}_f\right)^{\varepsilon-1}(\tau/\rho)^{1-\varepsilon}$. When the scale of the global market increases, we can see from the first-order condition $\frac{\partial B}{\partial L} > 0$, $\frac{\partial B'}{\partial L} > 0$ that both slopes will increase.
7. We already know that the overall average productivity equation is $\tilde{\varphi} = \left[\frac{1}{1 - G(\varphi^*)}\int_{\varphi^*}^{\infty} \varphi^{\varepsilon-1} g(\varphi) d\varphi\right]^{\frac{1}{\varepsilon-1}}$, $\varphi^* = \theta^*(\omega^*)^{1-\eta}$, meaning that when the threshold for

domestic productivity or export productivity declines, overall average productivity also falls.

8. When the other conditions remain unchanged, as the scale of two countries' markets becomes increasingly asymmetric, this study considers the case where the scale of the home (foreign) country market increases (decreases). Through the first-order condition $\frac{\partial B}{\partial \gamma}_{\gamma > \frac{1}{2}} > 0$, $\frac{\partial B'}{\partial \gamma}_{\gamma > \frac{1}{2}} < 0$, we see that the slope of the profit function for firms only capable of supplying the home market increases, whereas the slope of the profit function for domestic firms capable of exporting decreases. By contrast, the changes in slopes for foreign firms are the opposite.

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