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Market Structure, Competition Policies and Industrial Policies

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1 Introduction

1.1 Competition Policies in the Market with the Big and the Small

The market with large and small firms is an important market structure prevalent in many industries. Retailing, manufacturing, hotels, and the food industry are featured with the coexistence of a few big firms and a host of small firms. For instance, the supermarket industry in Japan is constituted by a few large supermarkets and a large number of small supermarkets (Igami, 2011). Another example is the electronics retailing industry in China, which consists of three to four large national retailers and numerous small local retailers. In such industries, large firms are usually able to manipulate the market by means of their pricing strategy and large-scale production, while small firms are negligible and may easily start or end their business due to their vulnerability to changes in the market although they can enjoy some market power by differentiation. Despite the negligible size of each small firm, the aggregation of all the small firms still occupies considerable market shares. In the confectionery market of Denmark, for instance, besides four major players, nearly 30% of the market was occupied by small producers (Source: Nielson 2012). Consequently, the role of these small firms should not be neglected in our analysis of firms' behavior in such a mixed market structure. The coexistence of large and small firms raises several questions. How will the large and small firms interact with each other? How much market power of the large firms will be diluted by the small firms? These questions entail a theoretical framework to capture this market structure.

In the industries characterized by the above-mentioned mixed market structure, several competition policies are carried out to regulate the behavior of firms, especially that of large firms. The large firms' entry to the local market has been of particular concern to the government. Several countries have enforced laws and regulations to restrict the entry and operation of large firms. In France, for instance, the Royer and Raffarin laws imposes severe restrictions on the entry of department stores in excess of 300 m^2. In Japan, the Large-scale Retail Store Law also had a stringent control over the large retail stores with the area over 1500 m^2 from the 1970s to the 1990s. Besides, various forms of zoning laws are carried out in many countries, such as the US, UK, India, Poland and Singapore. The main objectives of such legislative barriers of entry to the large firms are the protection of small firms, the preservation of product diversity and the interests of consumers. However, the legitimacy of these laws is questioned. According to Bertrand and Kramarz (2002), the Royer Law had a negative impact on employment and reinforced the market concentration. The contradiction between the desired result of the legal entry barriers and the empirical evidence necessitates a theoretical analysis on the impacts of a large firms' entry into the market with the big and small. How will the incumbent firms, which include both the large and small incumbents, change their behavior if there is a large entrant? Does the entry of the large firms generate adverse effects on consumer welfare and social welfare?

Apart from entry, merger and acquisition (M&A) is another controversial issue for its potential anti-competitiveness. To tackle this issue, antitrust laws are designed to prevent mergers and acquisitions that weaken the competition in the market because it is recognized that lessened competition is harmful to consumer and social welfare. At the same time, it is also evident that firms enjoy cost synergies after merger, which is beneficial to the industry with efficiency gains. Nevertheless, the impact of M&A on the competitiveness of the market is not a clear-cut solution, especially in the market with firms of different sizes. What strategies will the merged firm adopt? What will be the different reactions of non-participating large and small firms to merger? Is merger welfare deteriorating or improving in this mixed market structure?

To answer the questions raised above, this dissertation establishes theoretical frameworks to 1) describe the market with the big and the small, 2) examine the impacts of a large firm's entry on incumbents' behavior and social welfare, and 3) analyze the changes in firms' behavior and welfare after merger. Our findings may provide some implications for the criteria of the entry and antitrust legislations.

1.2 Industrial Policies

Industrial polices, generally treated as the complement to market mechanism, plays an important role in stimulating the economic development in developing economies. A large number of developing countries have already benefited a lot from their own industrial policies, such as China, India, Bangladesh and Brazil. Broadly speaking, the goals of carrying out industrial policies include, but are not restricted to, thestimulation of the (infant) industrial development and upgrading, the adjustment of the industrial structures and the corrections of market failures. In developing countries, such industrial policies include the attraction of international factors like foreign direct investment (FDI), skilled immigration and unskilled immigration, public infrastructure provisions, encouragement of firms' research and development behaviors, production subsidies, tariff protection and human capital investment, etc. Various industrial policies exert different socioeconomic impacts on the whole economy. Evaluating socioeconomic impacts generated by the industrial policies is of great importance both from the perspective of academic research and that of policy making.

On the other hand, last several decades have witnessed globalization. Economic and trade liberation brings enormous benefits, with countries having more development opportunities and people enjoying more diverse choices of consumption, education and work. However, globalization is a double-edge sword, as evidenced by the growing skilled-unskilled wage inequality in many developing countries. For instance, as suggested by Berman et al. (1998) and Berman and Machin (2000)\, the skilled-unskilled wage gap has gone up by

8% in a sample of 35 developed and developing economies. Other empirical studies–typically exemplified by Robbins (1996), Feenstra and Hanson (1996), Wood (1997), Khan (1998), Feenstra and Hanson (2003), Lam and Liu (2011) and Mehta and Hasan (2012)–also show that the increasing skilled-unskilled wage gap appeared in South Asia and Latin America. Therefore, when we analyze the industrial policies, how they interact with skilled-unskilled wage inequality and economic development should be paid much attention.

1.3 The Structure of the Dissertation

The rest of the dissertation is constituted by five chapters. We provide an overview of each chapter as follows.

Chapter 2

In this chapter, we review the literature on the market with the coexistence of large and small firms as well as the studies on industrial policies.

Chapter 3

This chapter studies the impacts of large firms' entry in the market with large and small firms by combining the Cournot model with the linear monopolistic competition model. Our model is characterized by the following three aspects. First, each large firm supplies a non-negligible range of product varieties, which is endogenously determined. Second, each small firm produces only one variety with a negligible quantity, but can freely enter or exit from the market. Third, the substitutability of products may differ across large and small firms. All firms move simultaneously.

Our findings are as follows. The different product substitutabilities between large and small firms play a critical role in determining the impacts exerted by the entry of the large firm. When the products of large firms and those of small firms have different levels of substitution, the entry of the large firm may cause a rise or a fall of the incumbent large firms' output, price and profit, depending on the comparison of the substitutability within large firms and small firms and the substitutability across these two types of firms. If the substitutability across these two types of firms is relatively larger than the substitutability within large firms and small firms, the squeezing effect due to the shrinkage of the competitive fringe outweighs the substitution effect among large firms, causing a rise in the market power of the large firms. Otherwise, the squeezing effect is not strong enough to compensate for the substitution effect among large firms, and consequently the large firms have to reduce their price and output. In addition, the welfare effects are also ambiguous.

The contribution of Chapter 3 is as follows. First, we relax the assumption of the same substitution level among the products of all firms in existing literature by introducing different levels of substitution across the large and small firms. Our findings explain the distinct impacts of a large firm's entry on the incumbents' behavior in different industries, such as the Japanese supermarket industry and the Korean furniture industry. Second, combining the Cournot model and the linear monopolistic model, we establish a partial equilibrium framework to capture the market with large and small firms. Different from Shimomura and Thisse (2012), who characterize a similar market structure with a general equilibrium framework, our model provides a simple but flexible analysis of firms' behavior within industries. Third, our model endogenizes the product range of large firms, which corresponds to the empirical evidence that large firms adjust their product scope periodically (Bernard et al., 2010).

Chapter 4

Chapter 4 employs a quasi-linear utility function of differentiated goods to investigate how the bilateral merger between large firms influences social welfare and the competitive fringe (measured by the number of small firms). We introduce the choice on product range to the ex post merged large firm's production decision process. The merged large firm can either choose to withdraw a brand or maintain two brands. Because maintaining a brand incurs huge fixed cost, such as advertising and distribution, which takes a large amount of the firm's revenue, it is reasonable for the merged large firm to withdraw a brand if the fixed cost is too high.

We find that it may be profitable for the merged firm to withdraw a brand when marginal cost synergy is small compared to the fixed cost synergy from brand withdrawal. In addition, the merged firm's different choices of product range generate opposing impacts on the competitive fringe and social welfare. If the merged firm chooses to withdraw a brand, the competitive fringe would expand, but consumer welfare would deteriorate. In contrast, the decision to maintain two brands would shrink the competitive fringe and improve consumer welfare.

Chapter 4 contributes to two strands of literature. First, it contributes to the literature on merger by incorporating the presence of small firms (competitive fringe) in the same market. In contrast to the canonical wisdom that outsiders free ride from merger in Cournot competition, we show that the non-merging big firms are not affected, owing to the buffering effect of small firms. Different from Lommerud and Sogard (1997), who show that the withdrawal of a brand by the insider generates an ambiguous effect on consumer welfare, we find that such a post-merger product choice raises consumer welfare because of the induced entry of small firms. Second, as far as we know, it is the first work to investigate the merger issue in the market structure with large and small firms. Thus, it contributes to the literature on the market with large and small firms by investigating a new issue and providing related policy implications.

Chapter 5

In Chapter 5, we establish four-sector general equilibrium models to investigate the impacts of increased governmental investment in education capital on the skilled-unskilled wage inequality and economic development. The basic model, which assumes perfect competition in the producer services sector, shows that increased education capital investment from the government will unambiguously reduce skilled-unskilled wage inequality. Economic development hinges on the role of the manufacturing sector, which should occupy a sufficiently large share of national income and expand in terms of its output.

However, our result shows that increased education capital from the government does not necessarily raise the manufactured output, leaving an ambiguous impact on the economic development. Only on certain conditions can government's policy of increasing education capital stimulate the manufacturing production. Thus, increased governmental investment in the education sector would conditionally promote economic development. The robustness of the basic model is substantiated by the extended model that incorporates the monopolistic competition feature in the producer services sector.

Chapter 5 contributes to existing theoretical research in three aspects. First, we try to address the issue of skilled-unskilled wage inequality from the perspective of the rising governmental investment in education, a perspective that has been largely neglected in existing works on the growing skilled-unskilled wage inequality in developing economies. Second, this chapter is complementary to the existing literature concerning skill formation because it examines a different government policy. Third, this chapter considers a vertically related market structure with the employment of different types of labor, i.e. the vertical relation between the high-skill producer services sector and the low-skill manufacturing sector, but existing literature on skill formation just considers horizontal relations among production sectors. Our modelling strategy enables us to explore how the vertical structure influences the labor market and the skilled–unskilled inequality.

Chapter 6

Chapter 6 provides the concluding remarks, the limitations of the current research and future agenda.

2 Literature Review

2.1 Literature on the Market with the Big and the Small

There are mainly four strands of literature that try to capture the different characteristics of the big and the small, which are the dominant firm model, the Stackelberg model, the models with firm heterogeneity and the recent works represented by Shimomura and Thisse (2012).

The first strand is the widely used dominant firm model, which models the dominant firm as the leader and the price maker, while assumes that small firms (or fringe firms) are the followers who face increasing marginal cost and behave like price takers. The dominant firm model pictures a market in which one large firm has a major share of total sales, and a group of smaller firms supplies the remainder of the market. A dominant firm exists because it has lower marginal cost than the other fringe firms. In this model, the fringe firms are completely inactive and their behavior is the same as the behavior of firms in perfect competition. Representative works include Chen (2003) and Gowrisankaran and Holmes (2004), etc.

The second strand employs the traditional Stackelberg model to differentiate the large firms from the small firms, as represented by Etro (2004, 2006) and Ino and Matsumura (2012), etc. In their models, the firm is large in the sense that it is both the leader and the first mover. The small firms are followers but their individual behavior influences the market price. These works also assume that large and small firms supply homogeneous goods.

The third strand distinguishes the big from the small by assigning firm heterogeneity across these two types of firms. Ishibashi and Matsushima (2009) examines a market with high-end and low-end firms. Matsumura and Matsushima (2010) investigates an asymmetric duopoly that consists of an inefficient (small) firm and an efficient (large) firm. These works try to explore the distinctions of quality or technology between the big and the small in an oligopolistic market structure.

However, none of these three strands of literature fully capture the features of the market structure elaborated in the introduction. Both the dominant firm model and the Stackelberg model investigate a homogeneous good market. Nevertheless, as shown earlier, firms in many industries supply differentiated products, which may not be characterized by these models. In both of these two models, moreover, the large firms are endowed with the commitment power. In reality, nonetheless, the large firms do not necessarily move before the small firms and may adjust their behavior in accordance to the aggregate behavior of small firms afterward. The third strand of literature examines an oligopolistic market, yet there is a sharp gap between the market power enjoyed by the big and that of the small, which is not captured by this strand of works.

The absence of a good theory to explain the market with big and small firms calls for a new framework that can characterize the interactions between the market structure and firms' strategies in this mixed market. The seminal work by Shimomura and Thisse (2012) establishes a general equilibrium framework to characterize the polarization of the big and the small without assuming the first-mover advantage of the large firms. In addition, unlike the first two strands of literature, which mainly deal with the homogeneous good market, Shimomura and Thisse (2012) focus on the differentiated good market.

Specifically, Shimomura and Thisse (2012) combine the Cournot competition model with the Dixit-Stiglitz monopolistic competition model in a nested CES framework. The large and small firms are differentiated in two respects. First, the large firms are modelled as oligopolistic players with a market impact, while the small firms are modelled as monopolistic competitors with a negligible market impact. They realize this distinction by assigning each big firm with a positive measure and each small firm with a zero measure. The second difference lies in the freedom of entry. The large firms are incumbent firms, while the small firms can freely enter or exit from the market. They do the static comparative analysis to investigate the impact of the entry of a large firm on firms' behavior and social welfare. Surprisingly, they find that a large entrant expands the production of large firms and raises social welfare. This result is contrary to the canonical argument in Cournot competition that the entry of a new firm would reduce the production of incumbents. The reason for their result lies in the market expansion effect on large incumbent firms due to the shrinkage of the competitive fringe (small firms).

2.2 Literature on Industrial Policies

The increasing skilled-unskilled wage inequality in developing countries arouses great interest of economic theorists in developing countries. Many of them try to clarify the relations between industrial policies and the growing skilled-unskilled wage gap. In addition, among those studies, some of them also focus on the relations between industrial policies and economic development. The current literature can be roughly divided into the following three categories.

The first category tries to analyze the widening skilled-unskilled wage gap by considering the international factor mobility, investment liberalization and trade liberalization policies. The related works include to Wu (2001), Das (2002), Marjit and Kar (2005), Anwar (2006), Chaudhuri and Yabuuchi (2007), Yabuuchi and Chaudhuri (2007), Beladi et al. (2008), Anwar (2008a), Beladi et al (2010), Gupta and Dutta (2010) Beladi et al (2011), and Pan and Zhou (2013). These studies contend that those policies only conditionally increase the skilled-unskilled wage inequality in developing economies, and the relevant conditions are also discussed in their research. Later on, scholars extend the existing theoretical models by accommodating the production of non-traded goods to investigate the impact of international factor mobility on the skilled-unskilled wage gap. Typically, Marjit and Acharyya (2003) and Oladi et al. (2011) investigate the impact of international factor mobility on the skilled-unskilled wage inequality in the presence of the production of non-traded goods. They claim that those policies still conditionally increase the wage gap between skilled labor and unskilled labor, but compared with the previous models which do not take the non-traded good production into account, the economic mechanisms of how these polices influence the wage inequality are more complex. Among the above-mentioned literature, some of them also pay attention to how the international factor mobility and economic liberalization policies influence the economic development. Still, the eventual findings imply ambiguous relations.

The second category concentrates on the relations among the growing public infrastructure provision, skilled-unskilled wage gap and economic development. The representative literature can be exemplified by Anwar (2008b), Anwar (2008c), Pi and Zhou (2012), Pi and Zhou (2014), Pi and Zhou (2015) and Pan (2015) among others. In Anwar (2008b), Anwar (2008c) and Pi and Zhou (2014). Although the public infrastructure provision is not the policy variable, the policies discussed in their papers are generally increasing the public infrastructure provision, which plays an important role in determining the skilled-unskilled wage inequality and economic development. Hence, their results implicitly imply the relations among the growing public infrastructure provision, wage inequality and economic development. They conclude that the growing public infrastructure will conditionally increase the skilled-unskilled wage inequality and stimulate economic development. Pi and Zhou (2012) and Pi and Zhou (2015) consider the cases of urban-biased and rural biased public infrastructure provisions separately. They argue that in both cases, the growing public infrastructure can also only conditionally increase the skilled-unskilled wage inequality and stimulate the economic development. In contrast to Pi and Zhou (2012) and Pi and Zhou (2015), Pan (2015) considers the factor-biased public infrastructure provision in agricultural sectors. She concludes that the agricultural neutral and land-biased public infrastructure provisions can decrease the skilled-unskilled wage gap, but still exerts an ambiguous effect on economic development.

The third category of literature highlights how the reduction of rent-seeking behaviors in industries, labor market deunionization policies and industrial adjustment policies influence the skilled-unskilled wage gap. Compared with the previous two categories, there are few works in this strand. Represented literature includes Kar and Khasnobis (2006), Chaudhuri and Yabuuchi (2007), Yabuuchi and Chaudhuri (2009), Mandal and Marjit (2010) and Pi and Zhou (2013). They also contend that these policies unambiguously or conditionally result in the increased wage gap, but through similar channels.

3 Competition among the Big and the Small with Different Product Substitution

3.1 Introduction

Many industries consist of a few large firms and a large number of small firms, such as retailing, manufacturing, and catering. The large firms are usually influential in the market, able to affect the market price of the products, while the small firms' impacts are negligible. It is questionable whether the standard imperfect competition theory still works to describe the market where the large and small firms coexist. As argued by Shimomura and Thisse (2012), neither oligopoly nor monopolistic competition can fully capture such a market. Thus, it is worth investigating firms' behavior and social welfare in this market structure.

Moreover, different industries with the coexistence of large and small firms see distinct changes in firms' behavior after the entry of a large firm. According to the empirical study by Igami (2011), in the supermarket industry in Japan, after the relaxation of the Big Retail Store Law which induced the entry of large supermarkets, large supermarkets were inclined to shrink (or even exit) but small supermarkets responded positively. Nevertheless, firms reacted differently in the Korean furniture market. After the entry of IKEA into Korea in 2014, the large national furniture makers, such as HANSSEM and LIVART, enjoyed an increase in their revenue. After the establishment of the IKEA store in Gwangmyeong, the revenue of Livart's Gwangmyeong branch increased 27%, while Hanssem's Gwangmyeong store saw a 10% rise in sales over the same period of the previous year. Small furniture makers, however, suffered from over 70% decrease in their revenue on average, and many were at the edge of shutdown.[1] These two contrasting cases invite us to wonder why the impacts

[1] Source: John Choi. "Korea's Large Furniture Makers Boost Revenues Thanks to IKEA." Korea Bizwire. March 27, 2015. http://koreabizwire.com/koreas-large-furniture-makers-

exerted by a large firm's entry vary across different industries.

In reality, some governments implicitly or explicitly restrict the entry of large firms into local markets with laws and regulations, such as the Royer-Raffarin Law in France and zoning laws in UK, Poland, Korea and India, etc. However, it is worth examining whether the barriers to the large firms' entry set by the government have a sound theoretical ground.

The present paper studies the impacts of large firms' entry in the market with large and small firms by combining the Cournot model with the linear monopolistic competition model. Our model is characterized by the following three aspects. First, each large firm supplies a non-negligible range of product varieties, which is endogenously determined [2]. Second, each small firm produces only one variety with a negligible quantity, but can freely enter or exit from the market. Third, the substitutability of products may differ across large and small firms[3]. All firms move simultaneously. We find that the different product substitutabilities between large and small firms play a critical role in determining the impacts exerted by the entry of the large firm. When the products of large firms and those of small firms have different levels of substitution, the entry of the large firm may cause a rise or a fall of the incumbent large firms' output, price and profit, depending on the comparison of the substitutability within large firms and small firms and the substitutability across these two types of firms. If the substitutability across these two types of firms is relatively larger than the substitutability within large firms and small firms, the squeezing effect due to the shrinkage of the competitive fringe outweighs the

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[2]Bernard et al. (2010) show that multi-product firms are almost omnipresent in the U.S. manufacturing industry. According to the data between 1979 and 1992, multi-product firms account for 41% of the total number of firms but supply 91% of total output. In addition, 89% of multi-product firms adjust their product range every five years.

[3]Our analytical framework is based on Singh and Vives (1984), Ottaviano and Thisse (1999) and Ottaviano et. al. (2002), but is distinct from them in the above-mentioned three respects.

substitution effect among large firms, causing a rise in the market power of the large firms. Otherwise, the squeezing effect is not strong enough to compensate for the substitution effect among large firms, and consequently the large firms have to reduce their price and output.

This may explain the different impacts of a large firm's entry in the Japanese supermarket industry and the Korean furniture market. In the Japanese supermarket industry, as Igami (2011) observes, the small size and convenience provides a dimension of differentiation for small supermarkets. Therefore, large supermarkets are less differentiated than small ones so that the squeezing effect is not strong enough to offset the competition effect for the large incumbents in the Japanese supermarket industry. On the contrary, with unique designs, the large furniture makers are more differentiated than small makers so that the squeezing effect outweighs the competition effect for large makers in the Korean furniture market. We also find that the welfare effects are ambiguous.

This paper is closely related to the seminal work by Shimomura and Thisse (2012). To the best of our knowledge, Shimomura and Thisse (2012) is the first paper that connects large oligopolistic firms and small monopolistic competitors. In a general equilibrium framework with CES utility, they show that in this mixed market structure, the entry of large firms increases the incumbent large firms' profit and raises welfare. This paper employs their idea of perceiving large firms as oligopolies and small firms as monopolistic competitors. However, we are distinct from Shimomura and Thisse (2012) in the following aspects. First, we establish a partial equilibrium framework with a quasi-linear utility function with quadratic subutility, while Shimomura and Thisse (2012) build a general equilibrium framework with CES utility. Part of our results is the same as Shimomura and Thisse (2012) if the income effects are washed out in their model. Second, different from Shimomura and Thisse (2012), which assumes large firms produce one variety, we consider large firms as multiproduct firms with endogenous choices on the product range to provide a more generalized result. We also test the robustness by assuming large firms as single-product firms in the discussion and find that our results hold qualitatively. Most importantly, we relax the assumption of the same elasticity of substitution among all firms in Shimomura and Thisse (2012) by assigning different levels of substitution across large and small firms. As we will see, the difference of substitution across large and small firms is our key distinction from Shimomura and Thisse (2012). We find that the different substitutabilities across large and small firms play a critical role in determining whether entry is beneficial or harmful to large firms and social welfare.[4]

The present paper is also related to other studies on the issues concerning the coexistence of large and small firms. The first strand is the widely used dominant firm model, which models the dominant firm as the leader and the price maker, while assumes that small firms are the followers who face increasing marginal cost and behave like price takers. Representative works include Chen (2003) and Gowrisankaran and Holmes (2004). Unlike the dominant firm model, we do not assume that small firms have increasing marginal cost or are price takers. Another strand is to use the traditional Stackelberg model to deal with such issues, as represented by Etro (2004, 2006) and Ino and Matsumura (2012), etc. In their models, the firm is large in the sense that it is both the leader and the first mover. The small firms are followers but their individual behavior influences the market price. The small firms and large firms can supply homogenous goods in a Stackelberg game. This paper is different from the Stackelberg model in that i) we consider a differentiated good market, ii) we do not assume the commitment power of the large firms, and iii) small firms are negligible in the market. Besides, some studies differentiate between large and small firms from the perspective of firm heterogeneity in quality (Ishibashi and Matsushima 2009) or technology (Matsumura and Matsushima, 2010). All in all, the present paper studies issues that are different from the above literature.

[4] Another related work is Parenti (2013), which adopts a framework similar to ours. However, he also assumes the level of substitution is the same across large and small firms and investigates a completely different issue.

The rest of the paper is organized as follows. We construct the model in Section 2. Results are shown in Section 3. Section 4 discusses the robustness of the established results.

3.2 The Model

Preference and demand

Consider a closed economy consisting of two sectors. Firms in sector 1 are perfectly competitive and produce the homogenous product under constant return to scale. Sector 2 provides the differentiated products that are produced by two types of firms. The first type of firms are large in size, and the number of these firms is exogenous. The second type of firms are infinitessimal and freely enter or exit from the market.

On the demand side, the large and small firms differ in three respects. First, each large firm imposes a non-negligible impact on the market and competes in an oligopolistic manner, while each small firm is negligible in the market and behaves as a monopolistic competitor. Here we follow the approach by Shimomura and Thisse (2012). Second, each large firm produces a range of varieties, and strategically chooses both the product range and the quantity of each variety, while each small firm only produces one variety of product. Third, the varieties are equally substitutable within the group of large firms and that of small firms, but the level of substitution across these two types of firms can be different.

The utility of the representative consumer U is described by a quasi-linear utility with a quadratic subutility:

$$
\begin{aligned}
U &= \alpha\Big[\int_0^N q_S(i)di + \sum_{m=1}^{M} \int_{\omega\in\Omega_m} q_L^m(\omega)d\omega\Big] \qquad (3.1)\\
&\quad -\frac{\beta}{2}\sum_{m=1}^{M} \int_{\omega\in\Omega_m} [q_L^m(\omega)]^2 d\omega - \frac{\beta}{2}\int_0^N [q_S(i)]^2 di \\
&\quad -\frac{\gamma_1}{2}\Big[\int_0^N q_S(i)di\Big]^2 - \frac{\gamma_2}{2}\Big[\sum_{m=1}^{M} \int_{\omega\in\Omega_m} q_L^m(\omega)d\omega\Big]^2 \\
&\quad -\gamma_3\Big[\int_0^N q_S(i)di\Big]\Big[\sum_{m=1}^{M} \int_{\omega\in\Omega_m} q_L^m(\omega)d\omega\Big] + q_0,
\end{aligned}
$$

where $q_S(i)$ is the quantity of small firm i with $i \in [0, N]$. The output of each small firm is of zero measure, and the total mass of small firms is N, describing the competitive fringe. The set of varieties produced by the large firm m ($m = 1, ..., M$) is represented by Ω_m, and the quantity for variety $\omega \in \Omega_m$ is $q_L^m(\omega)$. The total number of the incumbent large firms is M, with $M \geq 2$. Here we treat M and $|\Omega_m|$ as continuous variables. The output of sector 1 is q_0, which is treated as the numeraire. Consumer preferences are characterized by five parameters, which are α, β, and γ_i ($i = 1, 2, 3$). The intensity of preferences for the differentiated product is measured by $\alpha > 0$, which determines the size of the differentiated good market, whereas $\beta > 0$ implies the consumer's preference for a diversified consumption of products. The substitutability between varieties is characterized by γ_i ($i = 1, 2, 3$). Specifically, the substitutability among the varieties produced by small firms and that among the varieties of large firms are expressed by γ_1 and γ_2, respectively, and the cross substitutability between the varieties of large firms and those of small firms is expressed by γ_3. The products are closer substitutes when γ_i ($i = 1, 2, 3$) is higher. The products of the small and large firms have the same level of substitution when $\gamma_1 = \gamma_2 = \gamma_3$ and have different substitutabilities otherwise. Finally, to ensure the concavity of the quadratic subutility, we have $\beta/N + \gamma_1 > 0$,

$\beta/(M|\Omega|) + \gamma_2 > 0$, and $(\beta/N + \gamma_1)[\beta/(M|\Omega|) + \gamma_2] > \gamma_3^2$.[5] (See **Appendix 3-A**.)

The representative consumer's budget constraint is:

$$\int_0^N p_S(i)q_S(i)di + \sum_{m=1}^{M} \int_{\omega\in\Omega_m} p_L^m(\omega)q_L^m(\omega)d\omega + q_0 = I,$$

where $p_S(i)$ and $p_L^m(\omega)$ are the prices of small firm i and large firm m's variety ω, respectively. The representative consumer's income is I, which is exogenously given. The inverse demand functions facing small firms and large firms are determined by the maximization of the consumer's utility subject to the budget constraint:

$$p_S(i) = \alpha - \beta q_S(i) - \gamma_1 Q_S - \gamma_3 Q_L, \tag{3 .2}$$

$$p_L^m(\omega) = \alpha - \beta q_L^m(\omega) - \gamma_3 Q_S - \gamma_2 Q_L. \tag{3 .3}$$

where $Q_S \equiv \int_0^N q_S(i)di$ and $Q_L \equiv \sum_{m=1}^{M} \int_{\omega\in\Omega_m} q_L^m(\omega)d\omega$ are the total output of the small firms and that of the large firms, respectively.

Firms

Both large and small firms incur variable costs and fixed costs. All firms incur a common and constant marginal cost, which is normalized to zero, whereas the fixed cost may differ across the two types of firms.

Small firms

The profit function of the small firms is:

$$\Pi_S(i) = p_S(i)q_S(i) - (f^e + f^p),$$

where $\Pi_S(i)$ is the profit of small firm i, and f^e and f^p are the entry cost and fixed production cost of the small firm, respectively. To simplify our denotation and explanation, we denote $f \equiv f^e + f^p$ as the total fixed cost of a small firm.

[5] Here γ_i $(i = 1, 2, 3)$ can be negative as long as the conditions for the concavity of the utitility function hold. Hence the products can be complementary among the firms. We focus on the case when the products are substitutes in the rest of our analysis.

Plugging $p_S(i)$ of equation (3.2) into the above profit function, $\Pi_S(i)$ can be rewritten as:

$$\Pi_S(i) = \alpha q_S(i) - \beta[q_S(i)]^2 - [\gamma_1 Q_S + \gamma_3 Q_L]q_S(i) - f, \qquad (3.4)$$

Each small firm maximizes its profit with respect to its quantity $q_S(i)$.

The free entry and exit of small firms pins down the equilibrium profit of the small firm to zero:

$$\Pi_S(i) = \alpha q_S(i) - \beta[q_S(i)]^2 - [\gamma_1 Q_S + \gamma_3 Q_L]q_S(i) - f = 0. \qquad (3.5)$$

Large firms

The profit of the large firm is:

$$\Pi_L^m(\Omega_m, q_L^m(\omega)) = \int\limits_{\omega\in\Omega_m} (p_L^m(\omega)q_L^m(\omega) - F)d\omega,$$

where $\Pi_L^m(\Omega_m, q_L^m(\omega))$ is the profit of large firm m, and F is the fixed production cost for the large firm to produce one variety. [6]

Substituting $p_L^m(\omega)$ of equation (3.3) into the above profit function, $\Pi_L^m(\Omega_m)$ can be rewritten as:

$$\begin{aligned}\Pi_L^m(\Omega_m, q_L^m(\omega)) &= \{\alpha - \gamma_3 Q_S - \gamma_2[\sum_{k\neq m}\int\limits_{\omega\in\Omega_k} q_L^k(\omega)d\omega]\}[\int\limits_{\omega\in\Omega_m} q_L^m(\omega)d\omega] \qquad (3.6)\\ &\quad -\beta\int\limits_{\omega\in\Omega_m}[q_L^m(\omega)]^2 d\omega - \gamma_2[\int\limits_{\omega\in\Omega_m} q_L^m(\omega)d\omega]^2 - F\,|\Omega_m|\,.\end{aligned}$$

The large firm maximizes its profit with respect to both its product range Ω_m and the quantity of each variety $q_L^m(\omega)$. Note that the varieties do not overlap with each other.

All firms behave simultaneously. The equilibrium is mainly characterized by the mass of small firms N^*, the output of the small firm $q_S^*(i)$, the product range of the large firm $|\Omega_m^*|$, and the output of each variety for the large firm

[6] Here we do not consider the free entry and exit of large firms. Therefore, the entry cost for the incumbent large firms is normalized to zero.

$q_L^{m*}(\omega)$. These variables are determined by the profit maximization of the small firm with respect to $q_S(i)$, the free entry condition of small firms, and the profit maximization of the large firm with respect to $|\Omega_m|$ and q_L^m.

Social Welfare

The social welfare comprises consumer surplus and producer surplus. Consumer surplus is measured by:

$$CS = U - I,$$

Hence, the change of consumer surplus is the same as that of consumer's utility.

Since small firms earn zero profit, producer surplus is given by the sum of all large firms' profits:

$$PS = \sum_{m=1}^{M} \Pi_L^m,$$

Then, social welfare SW is the sum of consumer surplus and producer surplus:

$$SW = U - I + \sum_{m=1}^{M} \Pi_L^m. \quad (3.7)$$

3.3 Results

In this section, we derive the equilibrium results and conduct the comparative static analysis to investigate the impacts of the entry of a large firm on the other firms' behavior and social welfare.

Small Firms

A small firm only accounts for the impact of the market's total production because its own impact on the market is negligible. The small firm maximizes its profit given by equation (3.4) with respect to its output $q_S(i)$, yielding the optimal quantity of the small firm for an expected total output of large firms Q_L and mass of small firms N:

$$q_S^*(Q_L, N) = \frac{\alpha - \gamma_3 Q_L}{2\beta + \gamma_1 N}. \quad (3.8)$$

Using equation (3.2), the price of the small firm can be expressed by:

$$p_S^*(Q_L, N) = \beta \frac{\alpha - \gamma_3 Q_L}{2\beta + \gamma_1 N}. \tag{3 .9}$$

Accordingly, the equilibrium price of the small firm decreases with the mass of small firms and the total output of large firms.

Entry and exit are free for small firms. Using equation (3.5) after plugging in (3.8) and (3.9), the equilibrium mass of small firms with a given total output of large firms Q_L is:

$$N^*(Q_L) = \frac{1}{\gamma_1}[\sqrt{\frac{\beta}{f}}(\alpha - \gamma_3 Q_L) - 2\beta]. \tag{3 .10}$$

which decreases with the total output of large firms.

Substituting (3.10) into (3.8), the optimal quantity of each small firm is:

$$q_S^* = \sqrt{\frac{f}{\beta}}.$$

Owing to free entry and exit, the quantity produced by the small firm is independent of the behavior of large firms. In other words, the aggregate behavior of small firms responds to the change in the market condition only by adjusting the competitive fringe.

Plugging q_S^* into (3.9) yields the equilibrium price of small firms:

$$p_S^* = \sqrt{\beta f}.$$

Large Firms

Unlike small firms, large firms impose non-negligible impacts on the market. Large firm m maximizes its profit given by equation (3.6) with respect to its output $q_L^m(\omega)$, yielding the optimal quantity of each variety, given the total output of small firms Q_S, the total output of other large firms $Q_{-L} = \sum_{j \neq m} \int_{\omega \in \Omega_j} q_L^j(\omega) d\omega$, and its own product range $|\Omega_m|$:

$$q_L^{m*}(Q_S, Q_{-L}, |\Omega_m|) = \frac{\alpha - \gamma_3 Q_S - \gamma_2 Q_{-L}}{2(\beta + \gamma_2 |\Omega_m|)}. \tag{3 .11}$$

Everything else being equal, an increase in firm m's product range (larger $|\Omega_m|$) result in a reduction in the quantity of each variety, implying cannibalization.

The product range of large firm m, $|\Omega_m^*|$, that maximizes (3.6) after substituting (3.11) satisfies:

$$2(\beta + \gamma_2 |\Omega_m^*|) = \sqrt{\frac{\beta}{F}}[\alpha - \gamma_3 Q_S - \gamma_2 Q_{-L}]. \tag{3 .12}$$

We obtain the optimal output per variety for the large firm from equations (3.11) and (3.12):

$$q_L^{m*} = \sqrt{\frac{F}{\beta}}.$$

which is determined only by the fixed cost of large firms and the demand parameters, but independent of its product range or other firms' behavior. This implies that the large firm reacts to the change in the market condition only by adjusting its product range $|\Omega_m^*|$.

Substituting q_L^{m*} into equation (3.12), we obtain the equilibrium product range $|\Omega_m^*|$ given the expected aggregate output of small firms Q_S:

$$|\Omega_m^*| (Q_S) = \frac{\sqrt{\beta/F}(\alpha - \gamma_3 Q_S) - 2\beta}{\gamma_2(M+1)}. \tag{3 .13}$$

In equilibrium, the total output of big firms can be expressed by $Q_L^* = M |\Omega_m^*| q_L^{m*}$, and the aggregate output of small firms is $Q_S^* = N^* q_S^*$. Plugging these two expressions into (3.10) and (3.13), the mass of small firms and the product range of each big firm are:

$$\begin{aligned}
N^* &= \sqrt{\frac{\beta}{f}} \frac{\alpha[\gamma_2(M+1) - \gamma_3 M] - 2\sqrt{\beta}[\gamma_2(M+1)\sqrt{f} - \gamma_3 M \sqrt{F}]}{\gamma_1\gamma_2 + (\gamma_1\gamma_2 - \gamma_3^2)M}, \\
|\Omega^*| &= \sqrt{\frac{\beta}{F}} \frac{\alpha(\gamma_1 - \gamma_3) - 2\sqrt{\beta}(\gamma_1\sqrt{F} - \gamma_3\sqrt{f})}{\gamma_1\gamma_2 + (\gamma_1\gamma_2 - \gamma_3^2)M}.
\end{aligned}$$

Substituting N^*, $|\Omega^*|$, q_S^* and q_L^{m*} into equation (3.3), the price of the large firm in equilibrium is:

$$p_L^* = \sqrt{\beta F^p} + \frac{\gamma_2[\alpha(\gamma_1 - \gamma_3) - 2\sqrt{\beta}(\gamma_1\sqrt{F} - \gamma_3\sqrt{f})]}{\gamma_1\gamma_2 + (\gamma_1\gamma_2 - \gamma_3^2)M}.$$

Substituting the equilibrium range of varieties $|\Omega^*|$, the output of each variety q_L^{m*} and the equilibrium price of large firms p_L^* into equation (3.6), we obtain the equilibrium profit of the large firm:

$$\Pi_L^* = \frac{\gamma_2[\alpha(\gamma_1 - \gamma_3) - 2\sqrt{\beta}(\gamma_1\sqrt{F} - \gamma_3\sqrt{f})]^2}{[\gamma_1\gamma_2 + (\gamma_1\gamma_2 - \gamma_3^2)M]^2}.$$

And the total output is:

$$\begin{aligned} Q^* &= \frac{1}{\gamma_1\gamma_2 + (\gamma_1\gamma_2 - \gamma_3^2)M}\{\alpha M(\gamma_1 + \gamma_2 - 2\gamma_3) + \gamma_2(\alpha - 2\sqrt{\beta f}) \\ &\quad -2M\sqrt{\beta}[(\gamma_2 - \gamma_3)\sqrt{f} + (\gamma_1 - \gamma_3)\sqrt{F}]\}. \end{aligned}$$

We focus on the market with the coexistence of large and small firms. To ensure the market is mixed and stable in equilibrium, all the endogenous variables should be positive. The following proposition establishes the conditions.

Proposition 3.1 *There exists a unique mixed market equilibrium if the following three conditions hold:*

(i) $\alpha(\gamma_1 - \gamma_3) > 2\sqrt{\beta}(\gamma_1\sqrt{F} - \gamma_3\sqrt{f})$;

(ii) $\alpha[\gamma_2(M+1) - \gamma_3 M] > 2\sqrt{\beta}[\gamma_2(M+1)\sqrt{f} - \gamma_3 M\sqrt{F}]$;

(iii) $\gamma_1\gamma_2 + (\gamma_1\gamma_2 - \gamma_3^2)M > 0$.

Conditions (i) and (ii) ensure the existence of large firms and small firms, respectively. Condition (iii) is the sufficient condition to guarantee the stability of the established model (see **Appendix 3-B**). Conditions (i) and (ii) require that the market size should be sufficiently large, and conditions (ii) and (iii) also require the number of large firms should not be too large.

These three conditions can be illustrated by the aggregate reaction functions of the large and small firms. The aggregate reaction of large firms to the competitive fringe is:

$$Q_L(Q_S) = Mq_L^* \left|\Omega_m\right| (Q_S^*) = \frac{M}{\gamma_2(M+1)}(\alpha - 2\sqrt{\beta F} - \gamma_3 Q_S),$$

The aggregate reaction of the competitive fringe to the large firms is:

$$Q_S(Q_L) = \frac{1}{\gamma_1}(\alpha - 2\sqrt{\beta f} - \gamma_3 Q_L).$$

The coexistence of large and small firms in equilibrium requires that the two aggregate reaction functions intersect and the intersection be a stable equilibrium. Figure 3.1 depicts these two aggregate reaction functions. The stability of the intersection requires that the slope of $Q_L(Q_S)$ be flatter than the slope of $Q_S(Q_L)$, i.e. $\gamma_3 M/\gamma_2(M+1) < \gamma_1/\gamma_3$. This condition is equivalent to condition (iii). If condition (iii) does not hold, the mixed market equilibrium is not stable, resulting in the equilibrium with only small firms or the equilibrium with large firms only. To ensure that the two aggregate reaction functions intersect, two more conditions are necessary. On the horizontal axis, the intercept of $Q_S(Q_L)$ should be smaller than the intercept of $Q_L(Q_S)$, i.e. $(\alpha - 2\sqrt{\beta f})/\gamma_1 < (\alpha - 2\sqrt{\beta F^p})/\gamma_3$, which is equivalent to condition (i). On the vertical axis, the intercept of $Q_S(Q_L)$ should be larger than the intercept of $Q_L(Q_S)$, i.e. $(\alpha - 2\sqrt{\beta f})/\gamma_3 > (\alpha - 2\sqrt{\beta F^p})M/\gamma_2(M+1)$, which is equivalent to condition (ii).

[Figure 3.1 around here]

These three conditions imply that a unique mixed market equilibrium does not exist if $\gamma_1 < \gamma_3$. If $\gamma_1 < \gamma_3$, the substitutability from the large firms' variety to the small firm's is larger than the substitutability among the small firms' varieties, thus the large firm can expand its production so that all small firms are squeezed out of the market. In addition, if $\gamma_1 = \gamma_2 = \gamma_3$, condition (i) implies that $f > F$. That is, if the varieties are equally substitutable among all firms, the existence of large firms requires that the total fixed cost of a small firm should be larger than the large firm's fixed production cost of each variety. When the large and small firms share the same fixed production cost, the small firm's entry cost should be positive so that the large firm enjoys economies of scope (Parenti, 2013). Even when the small firm's entry cost is close to zero, the large firm may also exist if it is more efficient in producing each variety.

Finally, an increase in the number of large firms M generates a clockwise rotation of $Q_L(Q_S)$ around its intercept on the horizontal axis, resulting in a rise in the total output of large firms and a fall of the aggregate output of small firms.

In the rest of our analysis, we focus on the market where both large and small firms exist.

Now we investigate the impacts of a large firm's entry. Proposition 3.2 establishes the results.

Proposition 3.2 *The entry of a large firm will exert the following impacts on firms' behavior:*

(i) The output and price level of the small firm do not change;

(ii) The output of each variety of the large firm do not change;

(iii) The competitive fringe shrinks;

(iv) The product range, price, and profit of each large firm rise (fall) if $\gamma_1\gamma_2 < (>)\gamma_3^2$*, and remain to be the same if* $\gamma_1\gamma_2 = \gamma_3^2$*;*

(v) The total output increases if $\gamma_1 > \gamma_3$ *and remains to be the same if* $\gamma_1 = \gamma_3$*.*

Proof. See **Appendix 3-C**. ■

The first outcome is in line with the traditional monopolistic competition model. As shown by Figure 3.2, the free entry and exit of small firms shifts the demand curve such that there is only one equilibrium quantity, at which the average cost (AC) is tangent to the average revenue (AR) and marginal revenue (MR) intersects with marginal cost.

[Figure 3.2 around here]

The second result can be briefly explained as follows. The profit maximization of large firm m with respect to the output of each variety q_L^m yields $p_L^m - \beta q_L^m - \gamma_2 |\Omega_m| q_L^m = 0$, where the last term on the LHS is the internalization by the large firm. Applying the envelope theorem, the profit maximization of large firm m with respect to the product range $|\Omega_m|$ yields $p_L^m q_L^m - \gamma_2 |\Omega_m| (q_L^m)^2 = F$, where the second term on the LHS is the cannibalization effect. With linear demand and symmetric technology across varieties within the large firm, the cannibalization and internalization effects completely offset each other, and consequently the optimal output of each variety q_L^m is independent of the product scope $|\Omega_m|$. This implies that the large firm reacts to changes in the market condition by varying its product scope only.

The third result shows that the entry of a large firm may raise or reduce the prices and profits of the incumbent large firms when the substitutability across the products of large firms and those of small firms is different from the substitutability within the groups of large and small firms. To illustrate the mechanism, we establish the following two expressions:

$$p_S^* = \alpha - \beta q_S^* - \gamma_1 Q_S^* - \gamma_3 Q_L^*, \tag{3 .14}$$

$$p_L^* = \alpha - \beta q_L^* - \gamma_2 Q_L^* - \gamma_3 Q_S^*. \tag{3 .15}$$

The equilibrium conditions describing the demands for large and small firms, the profit maximization of large and small firms, and the free entry of small firms boil down to expressions (3.14) and (3.15). Here $Q_S^* = N^* q_S^*$ is the total output of small firms, and $Q_L^* = M\,|\Omega^*|\,q_L^*$ is the total output of large firms.

As shown by Figure 3.1, the entry of a large firm raises the equilibrium total output of large firms Q_L^*. Denote this increase in Q_L^* by ΔQ_L^*. Two opposing effects are generated by the entry of a large firm. First, according to equation (3.15), ΔQ_L^* generates a direct negative substitution effect on p_L^* by $-\gamma_2 \Delta Q_L^*$. Meanwhile, ΔQ_L^* also leads to the shrinkage of the competitive fringe, which has a positive effect on the large firms. As shown by the first argument in Proposition 3.2, p_S^* and q_S^* are not affected by a large firm's entry. According to equation (3.14), an increase in the total output of large firms ΔQ_L^* squeezes out the aggregate output of small firms by $\Delta Q_S^* = -(\gamma_3/\gamma_1)\Delta Q_L^*$. Then the substitution effect of the small firms on the large firms is weakened by the shrinkage of the competitive fringe, according to equation (3.15). Precisely, the indirect squeezing effect is measured by $(-\gamma_3)(-\gamma_3/\gamma_1)\Delta Q_L^* = (\gamma_3^2/\gamma_1)\Delta Q_L^*$. Therefore, whether the entry of a large firm raises or reduces the price of large firms depends on the comparison between the direct substitution effect and the indirect squeezing effect. If $\gamma_1\gamma_2 > \gamma_3^2$, which implies $-\gamma_2\Delta Q_L^* + (\gamma_3^2/\gamma_1)\Delta Q_L^* < 0$, then the negative substitution effect dominates the positive squeezing effect, and large firms have to reduce their price. Because $d\left|\Omega_m^*\right|/dM = (\sqrt{\beta/F}/\gamma_2)dp_L^*/dM$, in addition, the equilibrium product range of the large firm also shrinks, and consequently the equilibrium profit of each large firm decreases. If $\gamma_1\gamma_2 < \gamma_3^2$, on the other hand, then the positive squeezing effect dominates the negative substitution effect, and the price, product range and profit of each large firm rise. Finally, if $\gamma_1\gamma_2 = \gamma_3^2$, the positive squeezing effect exactly offsets the negative substitution effect, and consequently the large firms do not change their behavior. The last result is consistent with Shimomura and Thisse (2012) with the elimination of income effect and Parenti (2013).

Let us consider how the entry of large firm influences consumer welfare, producer surplus and social welfare. Proposition 3.3 establishes the results.

Proposition 3.3 *The entry of a large firm generates the following impacts on welfare:*

(i) Consumer welfare rises (falls) if $2E(\gamma_3^2-\gamma_1\gamma_2)M+D\sqrt{\beta}(\gamma_3\sqrt{f}-\gamma_1\sqrt{F}) < (>)0$*;*

(ii) Producer surplus rises (falls) if $\gamma_3^2 M - \gamma_1\gamma_2(M-1) > (<)0$*;*

(iii) Social welfare rises (falls) if $2\gamma_1\gamma_2 E + D\sqrt{\beta}(\gamma_1\sqrt{F} - \gamma_3\sqrt{f}) > (<)0$*.*

where $D = \gamma_1\gamma_2 + (\gamma_1\gamma_2 - \gamma_3^2)M > 0$*, and* $E = \alpha(\gamma_1 - \gamma_3) - 2\sqrt{\beta}(\gamma_1\sqrt{F} - \gamma_3\sqrt{f}) > 0$ *according to the conditions in Proposition 3.1.*

Proof. See **Appendix 3-D**. ■

Proposition 3.3 shows that the entry of the large firm will only conditionally raise consumer surplus, producer surplus and social welfare. Because the conditions are complicated, we decompose the impacts of a large firm's entry as follows.

The impact of a large firm's entry on consumer welfare can be expressed by:

$$\frac{dCS}{dM} = \frac{q_S^*}{2}\frac{dQ_S^*}{dM} + \frac{q_L^*}{2}\frac{dQ_L^*}{dM} - Q_L^*\frac{dp_L^*}{dM}.$$

The entry of a large firm generates three effects on consumer welfare. The first term represents the effect of the competitive fringe, which is negative. The second term represents the effect of the total output of large firms, which is positive. The third term represents the effect of large firms' price, which is ambiguous, depending on the relative levels of substitution across large and small firms.

The impact on producer surplus simply depends on the comparison between the profit of the large entrant and the change in the profits of the large incumbents. Producer surplus deteriorates only if the entry of the large firm leads to the reduction in the profit of large incumbents that outweighs the profit made by the entrant.

The impact on social welfare depends on the comparison between the negative effect of the competitive fringe and the positive effect of large firms' total output.

In particular, the sufficient condition for consumer surplus and social welfare to rise is $\gamma_3^2 < \gamma_1\gamma_2$ and $\gamma_3\sqrt{f} < \gamma_1\sqrt{F}$. Intuitively, $\gamma_3^2 < \gamma_1\gamma_2$ indicates that the substitutability across large and small firms should be relatively smaller than the substitutability within these two types of firms. In this case, the squeezing effect on the competitive fringe is dominated by the competition effect from the entry of a large firm, and consequently consumers benefit from the intensified competition among large firms. In addition, $\gamma_3\sqrt{f} < \gamma_1\sqrt{F}$, which is equivalent to $\sqrt{f/\beta} < (\gamma_1/\gamma_3)\sqrt{F/\beta}$, implies that switching from consuming the product of the small firm to the product of the large firm is beneficial to the consumer because the small firm's good is more substitutable than the large firm's good. Finally, the condition for an increase in producer surplus that is aligned to the sufficient conditions for consumer surplus and social welfare to rise is $\gamma_3^2 < \gamma_1\gamma_2$ and $\gamma_1\gamma_2 + (\gamma_1\gamma_2 - \gamma_3^2)M > 0$. Because the entry of a large firm results in a fall in the profit of each large firm when $\gamma_3^2 < \gamma_1\gamma_2$, according to Proposition 3.2, these two conditions imply that the producer surplus increases only when the profit earned by the entrant large firm outweighs the profit loss of the incumbent large firms. Therefore, the sufficient condition that increases consumer surplus, producer surplus, and social welfare is $\gamma_3\sqrt{f} < \gamma_1\sqrt{F}$, $\gamma_3^2 < \gamma_1\gamma_2$, and $\gamma_1\gamma_2 + (\gamma_1\gamma_2 - \gamma_3^2)M > 0$.

When $\gamma_3^2 > \gamma_1\gamma_2$, on the other hand, the entry of a large firm always increases producer surplus because the profit of each large firm is higher. As explained earlier, the increase in large firms' profits originates from weakened competition among large firms due to the squeezing effect on the competitive fringe. The government may be cautious of this case because consumer surplus and social welfare fall when $\gamma_3^2 > \gamma_1\gamma_2$, and $\gamma_3\sqrt{f} > \gamma_1\sqrt{F}$. In other words, the increase in producer surplus may be due to the mitigated competition in the market, which can be harmful to consumers and social welfare.

3.4 Discussion

In this section, we test the robustness of our results.

Single-product large firm When the varieties of large firms are exogenously given, say, $|\Omega_m| = 1$, both large and small firms are single-product firms. In this case, our results are robust, and the change in each large firm's output is qualitatively the same as the change in the large firm's variety choice in our original model. Specifically, the impact of a large firm's entry generates the same impacts on firms' behavior as in Proposition 3.2. The welfare effects are also ambiguous, with slight changes in the conditions. The conditions for the unique mixed market equilibrium are also modified. The following proposition establishes the results. (See **Appendix 3-E**)

Proposition 3.4 *When both large and small firms are single-product firms,* *(i) There exists a unique mixed market equilibrium if the following three conditions hold:*

(i-1) $\gamma_1(2\beta + \gamma_2) + (\gamma_1\gamma_2 - \gamma_3^2)M > 0$*;*

(i-2) $\alpha[2\beta + \gamma_2(M + 1) - \gamma_3 M] > 2\sqrt{\beta f}[2\beta + \gamma_2(M + 1)]$*;*

(i-3) $\alpha(\gamma_1 - \gamma_3) + 2\gamma_3\sqrt{\beta F} > [\gamma_1(2\beta + \gamma_2) + (\gamma_1\gamma_2 - \gamma_3^2)M]\sqrt{F/(\beta + \gamma_2)}$*.*

(ii) The impacts of a large firm's entry on firms' behavior are the same as Proposition 3.2.

(iii) The entry of a large firm generates the following impacts on social welfare:

(iii-1) Consumer welfare rises (falls) if $A\gamma_1(2\beta + \gamma_2) + B(\gamma_1\gamma_2 - \gamma_3^2)M > (<)0$*;*

(iii-2) Producer surplus rises (falls) if $I^2(\beta + \gamma_2)[\gamma_1(2\beta + \gamma_2) + (\gamma_1\gamma_2 - \gamma_3^2)M]/H^3 > (<)F$*;*

(iii-3) Social welfare rises (falls) if $B\gamma_1(2\beta+\gamma_2) + A(\gamma_1\gamma_2 - \gamma_3^2)M > (<)0$*.*

where $A = \alpha\beta(\gamma_1 - \gamma_3) - \gamma_2\gamma_3\sqrt{\beta f}$, $B = \alpha(\gamma_1 - \gamma_3)(3\beta + 2\gamma_2) + \gamma_3\sqrt{\beta f}(4\beta + 3\gamma_2)$, $H = \gamma_1(2\beta + \gamma_2) + (\gamma_1\gamma_2 - \gamma_3^2)M > 0$, *and* $I = \alpha(\gamma_1 - \gamma_3) + 2\gamma_3\sqrt{\beta f} > 0$ *according to the conditions in (i).*

This reduced model relates to Shimomura and Thisse (2012), who assume that large and small firms are single-product firms. Shimomura and Thisse (2012) show that the entry of a large firm shrinks the competitive fringe and thus generates the market expansion effect on large firms. This market expansion effect is amplified by the income effect, raising the profits of large firms and leading to a welfare-improving result. The key to their result is the income effect that amplifies the market expansion effect on the large firms. We distinguish our model from theirs by excluding the income effect and explicitly introducing the different substitutability between large and small firms. We conclude that the entry of the large firm may result in an increase or a decrease of each large firm's output, and may be harmful or beneficial to consumer surplus and social welfare, depending on the different levels of substitution across large and small firms.

Income effect As mentioned in Proposition 3.2, large firms do not change their behavior with the entry of a new large firm if $\gamma_1 = \gamma_2 = \gamma_3$, which corresponds to Shimomura and Thisse (2012) with the income effects washed out. Here we would like to elaborate more on the elimination of income effects in the CES framework.

The utility in Shimomura and Thisse (2012) is expressed by a nested Cobb-Douglas function with CES subutility of the differentiated good market:

$$U = \mathbf{Q}^{\alpha} X^{1-\alpha}.$$

where $\mathbf{Q} = [\int_0^N (q_S(i))^{\rho} di + \sum_{j=1}^{M} (q_L^j)^{\rho}]^{1/\rho}$ is the CES composite good, and $0 < \rho < 1$ is an inverse measure of the degree of differentiation across varieties. The consumption of the homogeneous good is represented by X, and α represents the substitution between the composite good and the homogeneous good, satisfying $0 < \alpha < 1$. As α falls, the consumption on the composite good also goes down, and it is readily shown that the income effect diminishes. With α approaching zero, the income effect becomes negligible, and the large firms' total profits play a negligible role in the consumer's expenditure on the composite good.

Another way to eliminate the income effect, as also mentioned by Shimomura and Thisse (2012), is to redistribute the profit to the absentee shareholders. In this case, the profits earned by large firms are not enjoyed and spent by the representative consumer, and consequently the income is exogenously given.

The third way to eliminate the income effect is to nest the CES composite good in a quasi-linear utility function:

$$U = \mathbf{Q} + q_0.$$

where $\mathbf{Q}$ is the composite good as before, and q_0 is the numeraire good. This utility function is in the spirit of existing monopolistic competition literature, such as Krugman (1979, 1980), Feenstra and Ma (2007), etc. It is readily shown that the free entry and exit of small firm fixes $\mathbf{Q}$, which is independent of the number of large firms. As a consequence, the behavior of the large firm does not change with the entry of a large firm.

Other discussion Finally, we also find that the entry of a large firm will qualitatively exert the same impacts achieved by Propositions 3.1, 3.2, and 3.3 if we consider the following cases.

(i) Large firms and small firms are vertically differentiated. In this case, α is replaced by α_L for the large firm and by α_S for the small firm. If $\alpha_L > (<)\alpha_S$, the products of the large firms have a higher (lower) quality than the small firms.

(ii) Large firms and small firms have the same or different marginal costs. In the constant marginal cost case, the variable costs of the big and small firms are respectively $c_L q_L$ and $c_S q_S$. If firms incur increasing marginal cost, the variable costs of the big and small firms can be represented by $c_L q_L^2/2$ and $c_S q_S^2/2$respectively.

3.5 Appendices

Appendix 3-A The necessary and sufficient conditions for the concavity of the quadratic subutility function

To ensure the concavity of the quadratic subutility function, the second-order condition should be negative definite. Although we have infinite varieties of big and small firms, we take the grid points to approximate the utility.

Consider $x_S(i)$, $i \in [0, N]$, and $x_L(j)$, $j \in [0, |\Omega_m|]$. Suppose the number of small firms is n_S, and the number of varieties of large firm m is n_L^m, $m = 1, ..., M$.

Take the grid points for the varieties of small firms and large firm m as $(N/n_S)i$, $i = 1, ..., n_S$ and $(|\Omega_m| /n_L^m)j$, $j = 1, ..., n_L^m$, respectively.

As long as $x_s(i)$, $i \in [0, N]$ and $x_L(j)$, $j \in [0, |\Omega_m|]$ are integrable, the utility function can be approximated by:

$$
\begin{aligned}
U &= \alpha[\sum_{i=1}^{n_S} x_s(\frac{N}{n_S}i)\frac{N}{n_S} + \sum_{m=1}^{M}\sum_{j=1}^{n_L^m} x_L^m(\frac{|\Omega_m|}{n_L^m}j)\frac{|\Omega_m|}{n_L^m}] \\
&\quad -\frac{\beta}{2}[\sum_{i=1}^{n_S} x_s(\frac{N}{n_S}i)^2\frac{N}{n_S} + \sum_{m=1}^{M}\sum_{j=1}^{n_L^m} x_L^m(\frac{|\Omega_m|}{n_L^m}j)^2\frac{|\Omega_m|}{n_L^m}] \\
&\quad -\frac{\gamma_1}{2}[\sum_{i=1}^{n_S} x_s(\frac{N}{n_S}i)\frac{N}{n_S}]^2 - \frac{\gamma_2}{2}[\sum_{m=1}^{M}\sum_{j=1}^{n_L^m} x_L^m(\frac{|\Omega_m|}{n_L^m}j)\frac{|\Omega_m|}{n_L^m}]^2 \\
&\quad -\gamma_3[\sum_{i=1}^{n_S} x_s(\frac{N}{n_S}i)\frac{N}{n_S}][\sum_{m=1}^{M}\sum_{j=1}^{n_L^m} x_L^m(\frac{|\Omega_m|}{n_L^m}j)\frac{|\Omega_m|_m}{n_L^m}].
\end{aligned}
$$

which limits to the original utility function as $n_S \to \infty$ and $n_L^m \to \infty$.

The second-order derivative of the quadratic subutility with respect to $x_S(i)$ ($i \in [0, N]$) and $q_L^m(j)$ ($j \in \Omega_m$) should be negative definite, i.e. for any $x \neq \mathbf{0}$, $-x^T Hx > 0$, where:

$$
\begin{aligned}
-x^T Hx &= \beta[\sum_{i=1}^{n_S} x_S(\frac{N}{n_S}i)^2\frac{N}{n_S} + \sum_{m=1}^{M}\sum_{j=1}^{n_L^m} x_L^m(\frac{|\Omega_m|}{n_L^m}j)^2\frac{|\Omega_m|}{n_L^m}] + \gamma_1[\sum_{i=1}^{n_S} x_S(\frac{N}{n_S}i)\frac{N}{n_S}]^2 \\
&\quad +\gamma_2[\sum_{m=1}^{M}\sum_{j=1}^{n_L^m} x_L^m(\frac{|\Omega_m|}{n_L^m}j)\frac{|\Omega_m|}{n_L^m}]^2 + 2\gamma_3[\sum_{i=1}^{n_S} x_S(\frac{N}{n_S}i)\frac{N}{n_S}][\sum_{m=1}^{M}\sum_{j=1}^{n_L^m} x_L^m(\frac{|\Omega_m|}{n_L^m}j)\frac{|\Omega_m|}{n_L^m}].
\end{aligned}
$$

We identify the necessary and sufficient condition for H to be negative definite in the following two steps. First, we find the minimized value $-x^T Hx$ in terms of β, γ_1, γ_2, γ_3 and x. Second, we identify the sufficient condition for the minimized value of $-x^T Hx$ to be positive.

Step 1:

Suppose $a = \sum_{i=1}^{n_S} x_S(\frac{N}{n_S}i)\frac{N}{n_S}$, and $b = \sum_{m=1}^{M}\sum_{j=1}^{n_L^m} x_L^m(\frac{|\Omega_m|}{n_L^m}j)$. Then:

$$
-x^T Hx = \beta[\sum_{i=1}^{n_S} x_S(\frac{N}{n_S}i)^2\frac{N}{n_S} + \sum_{m=1}^{M}\sum_{j=1}^{n_L^m} x_L^m(\frac{|\Omega_m|}{n_L^m}j)^2\frac{|\Omega_m|}{n_L^m}] + \gamma_1 a^2 + \gamma_2 b^2 + 2\gamma_3 ab.
$$

By Jensen's inequality, we have $\sum_{i=1}^{n_S} x_S(\frac{N}{n_S}i)^2\frac{N}{n_S} + \sum_{m=1}^{M}\sum_{j=1}^{n_L^m} x_L^m(\frac{|\Omega_m|}{n_L^m}j)^2\frac{|\Omega_m|}{n_L^m} \geq a^2/N + b^2/(M\,|\Omega_m|)$.

We normalize x such that $a^2 + b^2 = 1$. The minimization of the value of $-x^T Hx$ is then expressed as:

$$\min_{a,b} \beta(\frac{a^2}{N} + \frac{b^2}{M\,|\Omega_m|}) + \gamma_1 a^2 + \gamma_2 b^2 + 2\gamma_3 ab$$

$$\text{subject to } a^2 + b^2 = 1.$$

The Lagrangian function is

$$L = \beta(\frac{a^2}{N} + \frac{b^2}{M\,|\Omega_m|}) + \gamma_1 a^2 + \gamma_2 b^2 + 2\gamma_3 ab + \lambda(a^2 + b^2 - 1).$$

Here λ is the Lagrangian multiplier. The first order conditions of L with respect to a, b and λ yield

$$\begin{aligned} 2a(\frac{\beta}{N} + \gamma_1 + \lambda) + 2\gamma_3 b &= 0, \\ 2b(\frac{\beta}{M\,|\Omega_m|} + \gamma_2 + \lambda) + 2\gamma_3 a &= 0, \\ a^2 + b^2 &= 1. \end{aligned} \tag{3 .16}$$

To ensure the objective function is minimized, the Hessian matrix should be positive definite:

$$\begin{pmatrix} 2(\beta/N + \gamma_1 + \lambda) & \gamma_3 \\ \gamma_3 & 2(\beta/(M\,|\Omega_m|) + \gamma_2 + \lambda) \end{pmatrix}.$$

which requires $\beta/N + \gamma_1 + \lambda > 0$ and $\beta/M\,|\Omega_m| + \gamma_2 + \lambda > 0$. Hence:

$$\lambda = [-(\beta/N + \beta/(M\,|\Omega_m|) + \gamma_1 + \gamma_2) + \sqrt{(\beta/N + \gamma_1 - \beta/(M\,|\Omega_m|) - \gamma_2)^2 + 4\gamma_3^2}]/2.$$

Denote:

$$\Psi = \frac{-(p-q) + \sqrt{(p-q)^2 + 4\gamma_3^2}}{2}.$$

where $p = \beta/N + \gamma_1$, and $q = \beta/(M\,|\Omega_m|) + \gamma_2$.

Substituting λ into equation (3.16), we have $a = -\Psi b/\gamma_3$.

Let $\Theta = -x^T Hx$. Then,

$$\Theta = b^2(\frac{p}{\gamma_3^2}\Psi^2 - 2\Psi + q).$$

Step 2:

Now we identify the conditions on which Θ is positive. Observe that Θ is a quadratic function of Ψ. There are four combinations of p and q that determine the shape of Θ in terms of Ψ. We find the necessary and sufficient conditions for Θ to be positive in the following four cases.

1. $p > 0$ and $q > 0$.

In this case, Θ is a convex function of Ψ. A sufficient condition for Θ to be positive is $p/\gamma_3^2 > 0$ and $4 - 4pq/\gamma_3^2 > 0$. In other words, Θ is always positive if $p > 0$, $q > 0$, and $pq > \gamma_3^2$.

If $pq < \gamma_3^2$, $\Psi = [-(p-q)+\sqrt{(p-q)^2 + 4\gamma_3^2}]/2 > [-(p-q)+\sqrt{(p-q)^2 + 4pq}]/2 = q$. In addition, $(\gamma_3^2 - pq)^2 = \gamma_3^2(\gamma_3^2 - pq) - pq(\gamma_3^2 - pq) < \gamma_3^2(\gamma_3^2 - pq)$, implying that $\gamma_3^2 - |\gamma_3|\sqrt{\gamma_3^2 - pq} < pq$. Hence $\Psi > q > (\gamma_3^2 - |\gamma_3|\sqrt{\gamma_3^2 - pq})/p$. On the other hand, $pq < \gamma_3^2$ implies $q < \gamma_3^2/p$. Hence $\Psi = [q-p+\sqrt{(q-p)^2 + 4\gamma_3^2}]/2 < [\gamma_3^2/p-p+\sqrt{(\gamma_3^2/p - p)^2 + 4\gamma_3^2}]/2 = \gamma_3^2/p < (\gamma_3^2+|\gamma_3|\sqrt{\gamma_3^2 - pq})/p$. Therefore, $(\gamma_3^2-|\gamma_3|\sqrt{\gamma_3^2 - pq})/p < \Psi < (\gamma_3^2+|\gamma_3|\sqrt{\gamma_3^2 - pq})\gamma_3/p$, and Θ is consequently negative. Thus, $pq > \gamma_3^2$ is a necessary and sufficient condition to ensure a positive Θ in this case.

2. $p > 0$ and $q < 0$.

In this case, Θ is a convex function of Ψ. Since $pq < \gamma_3^2$ always holds, $(\gamma_3^2-|\gamma_3|\sqrt{\gamma_3^2 - pq})/p < 0 < \Psi < (\gamma_3^2+|\gamma_3|\sqrt{\gamma_3^2 - pq})/p$, and Θ is consequently negative.

3. $p < 0$ and $q > 0$.

In this case, Θ is a concave function of Ψ, and $pq < 0 < \gamma_3^2$ always holds. Then $(\gamma_3^2 - pq)^2 = \gamma_3^2(\gamma_3^2 - pq) - pq(\gamma_3^2 - pq) > \gamma_3^2(\gamma_3^2 - pq)$, implying that $\gamma_3^2 - |\gamma_3|\sqrt{\gamma_3^2 - pq} > pq$ and $[\gamma_3^2 - |\gamma_3|\sqrt{\gamma_3^2 - pq}]/p < q$. As shown earlier, $pq < \gamma_3^2$ implies that $\Psi > q$. Therefore, $\Psi > (\gamma_3^2 - |\gamma_3|\sqrt{\gamma_3^2 - pq})/p$, and Θ is consequently negative.

4. $p < 0$ and $q < 0$.

In this case, Θ is a concave function of Ψ. If $pq > \gamma_3^2$, Θ is always negative. If $pq < \gamma_3^2$, $\Psi > 0 > (\gamma_3^2 - |\gamma_3|\sqrt{\gamma_3^2 - pq})/p$, and Θ is consequently negative.

Summing up the above four cases, therefore, the subutility function is concave when $\beta/N+\gamma_1>0$, $\beta/(M|\Omega_m|)+\gamma_2>0$, and $(\beta/N+\gamma_1)(\beta/(M|\Omega_m|)+\gamma_2)>\gamma_3^2$.[7]

Appendix 3-B: Proof of Proposition 3.1

Given the equilibrium values of $q_S^*=\sqrt{f/\beta}$ and $q_L^*=\sqrt{F/\beta}$, the free entry condition of small firm and the profit maximization of large firm yield the following two expressions of dynamic adjustment process:

$$\dot{N}(N,|\Omega|)=d_1[\alpha q_S^*-\beta q_S^{*2}-(\gamma_1 N q_S^*+\gamma_3 M|\Omega|q_L^*)q_S^*-f],$$

$$|\dot{\Omega}|(N,|\Omega|)=d_2\{[\alpha-\beta q_L^*-\gamma_3 N q_S^*-\gamma_2(M+1)|\Omega|q_L^*]q_L^*-F\}.$$

where $\dot{N}=dN/dt$, $|\dot{\Omega}|=d|\Omega|/dt$, $d_1>0$ and $d_2>0$ are the speed of dynamic adjustment. Without loss of generality, set $d_1=d_2=1$. To ensure the local stability of the established model, the Jacobian matrix derived from the above two expressions is required to be negative definite:

$$J=\begin{pmatrix}\partial\dot{N}/\partial N & \partial\dot{N}/\partial|\Omega| \\ \partial|\dot{\Omega}|/\partial N & \partial|\dot{\Omega}|/\partial|\Omega|\end{pmatrix}=\begin{pmatrix}-\gamma_1 q_S^{*2} & -\gamma_3 M q_S^* q_L^* \\ -\gamma_3 q_S^* q_L^* & -\gamma_2(M+1)q_L^{*2}\end{pmatrix}.$$

$J^1=-\gamma_1 q_S^*<0$, and $J^2=[\gamma_1\gamma_2+(\gamma_1\gamma_2-\gamma_3^2)M]q_S^{*2}q_L^{*2}>0$. Hence $\gamma_1\gamma_2+(\gamma_1\gamma_2-\gamma_3^2)M>0$.

Appendix 3-C: Proof of Proposition 3.2

Let $D=\gamma_1\gamma_2+(\gamma_1\gamma_2-\gamma_3^2)M$, and $E=\alpha(\gamma_1-\gamma_3)-2\sqrt{\beta}(\gamma_1\sqrt{F}-\gamma_3\sqrt{f})$. By Proposition 3.1, $D>0$ and $E>0$. From the obtained results, we have:

$dq_S^*/dM=0$, $dp_S^*/dM=0$, $dq_L^*/dM=0$, and $dN^*/dM=-\gamma_2\gamma_3 E\sqrt{\beta/f}/D^2<0$. $dp_L^*/dM=\gamma_2(\gamma_3^2-\gamma_1\gamma_2)E/D^2$, $d|\Omega^*|/dM=(\gamma_3^2-\gamma_1\gamma_2)E\sqrt{\beta/F}/D^2$,

[7] The proof can be more general if we replace $M|\Omega_m|$ with $\sum_{m=1}^{M}|\Omega_m|$.

$d\Pi_L^*/dM = 2\gamma_2(\gamma_3^2 - \gamma_1\gamma_2)E^2/D^3$, which are positive if $\gamma_1\gamma_2 < \gamma_3^2$ and negative if $\gamma_1\gamma_2 > \gamma_3^2$, and $dQ^*/dM = \gamma_2(\gamma_1 - \gamma_3)E/D^2 \gtreqqless 0$.

Appendix 3-D: Proof of Proposition 3.3

The consumer surplus, producer surplus and social welfare can be expressed as:

$$\begin{aligned}
CS^* &= \alpha Q^* - \frac{\beta}{2}(N^* q_S^{*2} + M\,|\Omega^*|\,q_L^{*2}) - \frac{\gamma_1}{2}Q_S^{*2} \\
&\quad -\frac{\gamma_2}{2}Q_L^{*2} - \gamma_3 Q_S^* Q_L^* - p_S^* Q_S^* - p_L^* Q_L^*, \\
PS^* &= \frac{\gamma_2 M E^2}{D^2}, \\
SW^* &= \alpha Q^* - \frac{\beta}{2}(N^* q_S^{*2} + M\,|\Omega^*|\,q_L^{*2}) - \frac{\gamma_1}{2}Q_S^{*2} \\
&\quad -\frac{\gamma_2}{2}Q_L^{*2} - \gamma_3 Q_S^* Q_L^* - p_S^* Q_S^* - p_L^* Q_L^* + \frac{\gamma_2 E^2}{D^2}.
\end{aligned}$$

The impact of a marginal increase of M on consumer surplus is:

$$\frac{dCS^*}{dM} = -\frac{\gamma_2 E}{D^2}\left[\frac{EM(\gamma_3^2 - \gamma_1\gamma_2)}{D} + \frac{\sqrt{\beta}}{2}(\gamma_3\sqrt{f} - \gamma_1\sqrt{F})\right].$$

which is positive if $2E(\gamma_3^2 - \gamma_1\gamma_2)M + D\sqrt{\beta}(\gamma_3\sqrt{f} - \gamma_1\sqrt{F}) < 0$ and negative if $2E(\gamma_3^2 - \gamma_1\gamma_2)M + D\sqrt{\beta}(\gamma_3\sqrt{f} - \gamma_1\sqrt{F}) > 0$.

The impact of a marginal increase of M on producer surplus is:

$$\frac{dPS^*}{dM} = \frac{\gamma_2 E^2}{D^3}[\gamma_3^2 M - \gamma_1\gamma_2(M-1)].$$

which is positive (negative) if $\gamma_3^2 M - \gamma_1\gamma_2(M-1) > (<)0$.

The impact of a marginal increase of M on social welfare is:

$$\frac{dSW^*}{dM} = \frac{\gamma_2 E}{2D^3}[2\gamma_1\gamma_2 E - D\sqrt{\beta}(\gamma_3\sqrt{f} - \gamma_1\sqrt{F})].$$

which is positive if $2\gamma_1\gamma_2 E - D\sqrt{\beta}(\gamma_3\sqrt{f} - \gamma_1\sqrt{F}) > 0$ and negative if $2\gamma_1\gamma_2 E - D\sqrt{\beta}(\gamma_3\sqrt{f} - \gamma_1\sqrt{F}) < 0$.

Appendix 3-E: Proof of Proposition 3.4

(4-i) Given the equilibrium value of $q_S^* = \sqrt{f/\beta}$, the free entry condition of small firm and the profit maximization of large firm yield the following two expressions of dynamic adjustment process:

$$\dot{N}(N, q_L) = d_1[\alpha q_S^* - \beta q_S^{*2} - (\gamma_1 N q_S^* + \gamma_3 M q_L) q_S^* - f],$$

$$\dot{q_L}(N, q_L) = d_2\{[\alpha - 2\beta q_L^* - \gamma_3 N q_S^* - \gamma_2 (M+1) q_L]\}.$$

where $\dot{N} = dN/dt$, $\dot{q_L} = dq_L/dt$, $d_1 > 0$ and $d_2 > 0$. To ensure the local stability of the established model, the Jacobian matrix derived from the above two expressions is required to be negative definite:

$$J = \begin{pmatrix} \partial\dot{N}/\partial N & \partial\dot{N}/\partial q_L \\ \partial\dot{q_L}/\partial N & \partial\dot{q_L}/\partial q_L \end{pmatrix} = \begin{pmatrix} -\gamma_1 q_S^{*2} & -\gamma_3 M q_S^* \\ -\gamma_3 q_S^* & -2\beta - \gamma_2(M+1) \end{pmatrix}.$$

$J^1 = -\gamma_1 q_S^{*2} < 0$, and $J^2 = [\gamma_1(2\beta + \gamma_2) + (\gamma_1\gamma_2 - \gamma_3^2)M] q_S^{*2} > 0$. Hence $\gamma_1(2\beta + \gamma_2) + (\gamma_1\gamma_2 - \gamma_3^2)M > 0$.

(4-ii) Let $H = \gamma_1(2\beta + \gamma_2) + (\gamma_1\gamma_2 - \gamma_3^2)M$, and $I = \alpha(\gamma_1 - \gamma_3) + 2\gamma_3\sqrt{\beta f}$. By (4-i), $H > 0$ and $I > 0$. From the obtained results, we have:

$dq_S^*/dM = 0$, $dp_S^*/dM = 0$, and $dN^*/dM = -(\beta + \gamma_2)\gamma_3 I\sqrt{\beta/f}/H^2 < 0$. $dq_L^*/dM = (\gamma_3^2 - \gamma_1\gamma_2)I/H^2$, $dp_L^*/dM = (\beta + \gamma_2)(\gamma_3^2 - \gamma_1\gamma_2)I/H^2$, $d\Pi_L^*/dM = 2(\beta + \gamma_2)(\gamma_3^2 - \gamma_1\gamma_2)E^2/D^3$, which are positive if $\gamma_1\gamma_2 < \gamma_3^2$ and negative if $\gamma_1\gamma_2 > \gamma_3^2$, and $dQ^*/dM = (2\beta + \gamma_2)(\gamma_1 - \gamma_3)I/H^2$, which is positive (negative) if $\gamma_1 > (<) \gamma_3$.

(4-iii) The consumer surplus, producer surplus and social welfare can be expressed as:

$$\begin{aligned} CS^* &= \alpha Q^* - \frac{\beta}{2}(N^* q_S^{*2} + M\,|\Omega^*|\, q_L^{*2}) - \frac{\gamma_1}{2} Q_S^{*2} \\ &\quad -\frac{\gamma_2}{2} Q_L^{*2} - \gamma_3 Q_S^* Q_L^* - p_S^* Q_S^* - p_L^* Q_L^*, \\ PS^* &= \frac{\gamma_2 M I^2}{H^2}, \\ SW^* &= \alpha Q^* - \frac{\beta}{2}(N^* q_S^{*2} + M\,|\Omega^*|\, q_L^{*2}) - \frac{\gamma_1}{2} Q_S^{*2} \\ &\quad -\frac{\gamma_2}{2} Q_L^{*2} - \gamma_3 Q_S^* Q_L^* - p_S^* Q_S^* - p_L^* Q_L^* + \frac{\gamma_2 I^2}{H^2}. \end{aligned}$$

The impact of a marginal increase of M on consumer surplus is:

$$\frac{dCS^*}{dM} = \frac{I}{2H^2}[A\gamma_1(2\beta+\gamma_2) + B(\gamma_1\gamma_2 - \gamma_3^2)M].$$

where $A = \alpha\beta(\gamma_1-\gamma_3)-\gamma_2\gamma_3\sqrt{\beta f}$, and $B = \alpha(\gamma_1-\gamma_3)(3\beta+2\gamma_2)+\gamma_3\sqrt{\beta f}(4\beta+3\gamma_2)$. dCS^*/dM is positive if $A\gamma_1(2\beta+\gamma_2)+B(\gamma_1\gamma_2-\gamma_3^2)M > 0$ and negative if $A\gamma_1(2\beta+\gamma_2)+B(\gamma_1\gamma_2-\gamma_3^2)M < 0$.

The impact of a marginal increase of M on producer surplus is:

$$\frac{dPS^*}{dM} = \frac{(\beta+\gamma_2)E^2}{D^3}[\gamma_1(2\beta+\gamma_2) - (\gamma_1\gamma_2 - \gamma_3^2)M] - F.$$

which is positive if $(\beta+\gamma_2)I^2[\gamma_1(2\beta+\gamma_2)-(\gamma_1\gamma_2-\gamma_3^2)M] > H^3F$ and negative if $(\beta+\gamma_2)I^2[\gamma_1(2\beta+\gamma_2)-(\gamma_1\gamma_2-\gamma_3^2)M] < H^3F$.

The impact of a marginal increase of M on social welfare is:

$$\frac{dSW^*}{dM} = \frac{I}{2H^2}[B\gamma_1(2\beta+\gamma_2) + A(\gamma_1\gamma_2 - \gamma_3^2)M].$$

which is positive if $B\gamma_1(2\beta+\gamma_2)+A(\gamma_1\gamma_2-\gamma_3^2)M > 0$ and negative if $B\gamma_1(2\beta+\gamma_2)+A(\gamma_1\gamma_2-\gamma_3^2)M < 0$.

4 Merger of Big Firms with Product Choice in the Presence of Small Firms

4.1 Introduction

Many industries, such as retailing and food industry, feature the coexistence of a few big firms and a host of small firms. Within these industries, big firms are usually able to manipulate the market environment by means of their pricing strategy and large-scale production, while small firms could easily start or end their business due to vulnerability to changes in the market. Although small firms impose a negligible impact on the market outcomes, they can also enjoy some mark-up by differentiation.

Modelling and studying firms' production behavior within such a market is of great importance. As suggested by Shimomura and Thisse (2012), neither the traditional oligopolistic model nor the classical Dixit-Stiglitz monopolistic competition model can fully capture the features of the above-mentioned market structure and new models should be constructed. Practically, the production behavior of big firms, such as entry and merger, deserves the attention of policy makers because such behavior could strongly affect the market in terms of changing the size of small firms, the product varieties in the market and social welfare.

A few analytical frameworks have been built to investigate the above-mentioned mixed market structure, such as the dominant firm model (Gowrisankaran and Holmes, 2004) and Stackelberg model (with or without endogenous entry) (e.g., Etro, 2006). These models well explain the behavior of big and small firms in some scenarios, but cannot fully describe the polarized market structure mentioned above[8]. Recently, Kokovin et al. (2011) and Shimomura

[8]The dominant firm model generally treats big firms as the leader and price maker, while small firms as followers and price takers. The Stackelberg model (with or without endogenous entry) commonly use the leadership (or the action order) to distinguish big firms from small

and Thisse (2012) cast light on the way to model such a market structure. They combine the oligopolistic model and monopolistic competition model by treating big firms as oligopolists and small firms as monopolistic competitors. Nevertheless, the main focus of these two papers rests on the impacts of big firms' entry, but neither of them considers the merger among big firms. The study of merger may facilitate our understanding of firms' interactions as well as welfare effects within such a mixed market structure.

In addition, big firms also face the choice on product range after merger in this mixed market because maintaining a brand incurs high fixed cost, such as advertising and distribution. In the Chinese electronics retailing market,[9] Best Buy withdrew its own brand after merging with Five Star.[10] In the Chinese candy industry where big and small firms also coexist, in contrast, Nestle maintained the brand of Hsu Fu Chi after merger, and so did Hershey after it merged with Shanghai Golden Monkey Food Company.[11] Having captured lots of attention and some debates from governments and consulting companies, such a post-merger product choice deserve theoretical analysis.

The present paper modifies the framework of Shimomura and Thisse (2012) by employing a quasi-linear utility function of differentiated goods to investi-

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firms. Specifically, the market structure considered here is the influential big firms contrary to the negligible small firms with free entry in the differentiated good market. Besides, big and small firms behave simultaneously. Finally, the above-mentioned literature does not address the issues analyzed in the present paper.

[9] In this market, there are several big retailers, like Best Buy, Guo Mei, Su Ning and a number of small retailers that are mainly local brands.

[10] Details can be referred to "Tesco set to withdraw brand from China in new joint." The Guradian, 9 August, 2013.

[11] Hsu Fu Chi and Shanghai Golden Monkey Food Company are leading candy companies in China. For details of the mergers, please refer to "Nestle to Buy 60% Stake in Hsu Fu Chi for $1.7 Billion." http://www.bloomberg.com/news/articles/2011-07-11/nestle-to-buy-60-stake-in-chinese-snack-maker-hsu-fu-chi-for-1-7-billion and "Hershey acquires majority share of Shanghai Golden Monkey Food Co." http://www.candyindustry.com/articles/85993-hershey-acquires-majority-share-of-shanghai-golden-monkey-food-co.

gate how the bilateral merger between large firms influences social welfare and the competitive fringe (measured by the size of small firms)[12]. We introduce the choice on product range to the ex post merged big firm's production decision process. The merged big firm can either choose to withdraw a brand or maintain two brands. Because maintaining a brand incurs huge fixed cost, such as advertising and distribution, which takes a large amount of the firm's revenue, it is reasonable for the merged big firm to withdraw a brand if the fixed cost is too high[13]. We find that it may be profitable for the merged firm to withdraw a brand when marginal cost synergy is small compared to the fixed cost synergy from brand withdrawal. In addition, the merged firm's different choices of product range generate opposing impacts on the competitive fringe and social welfare.

This paper is also related to several works on merger, which mainly focus on the oligopolistic market. In the oligopolistic market with price competition, Deneckere and Davidson (1985) demonstrate that mergers are always beneficial for both merging firms (insiders) and non-participating firms (outsiders). In the market with quantity competition, on the contrary, it is not profitable to merge without sufficient synergy or resulting in a very high market concentration, while outsiders benefit more than the insiders (Stigler, 1950; Salant et al., 1983). These contrasting results are mainly attributed to that firms are strategic substitutes in quantity competition but strategic complements in price competition. Lommerud and Sorgard (1997) introduces the post-merger product choice into a three-firm oligopoly model. They show that it can be profitable for the merged firm to narrow its product range. When the outsider responds to a merger by introducing a new brand, in addition, the merger is

[12] It is reasonable for us to ignore the cases where a big firm acquires a small firm, or a small firm merges with another. Because the small firms are negligible here, such mergers have trivial impacts on the market outcomes and social welfare.

[13] Lommerud et al. (1997) also takes the merged firm's product choice into account. Their research question and market structure are quite different from ours, however.

never profitable although it can be welfare improving. Davidson and Muckherjee (2007) considers the impacts of merger with the free entry and exit of firms in an oligopolistic market of homogeneous goods. They find that the "free rider problem" in quantity competition diminishes owing to the potential entrants after merger, and quantity-setting and price-setting games yield similar predictions about profitability. However, these works do not consider the presence of small firms, which turns out to play a non-negligible role in the non-participating large firms' reaction to merger and the impacts of merger on social welfare, as will be shown in this chapter.

4.2 The Model

Preference and demand

The representative consumer consumes two types of goods. The first good is the homogenous good with quantity q_0 and considered as numeraire. The second good is the differentiated good, which is produced by two types of firms, the big and the small. The number of big firms is M, and the output level of big firm $j(=1,...,M)$ is q_L^j. In addition, there is a continuum of small firms with mass of N, with small firm $i(\in[0,N])$ producing at quantity $q_S(i)$ [14]. The market size of the differentiated product is measured by $\alpha>0$, $\beta>0$ represents the consumer's preference for variety, and $\gamma>0$ restricted by $\beta>\gamma$ measures the substitutability between varieties. The utility of the representative consumer is:

$$\begin{aligned} U &= \alpha[\int_0^N q_S(i)di+\sum_{j=1}^{M}q_L^j]-\frac{\beta-\gamma}{2}[\int_0^N (q_S(i))^2di+\sum_{j=1}^{M}(q_L^j)^2] \\ &\quad -\frac{\gamma}{2}[\int_0^N q_S(i)di+\sum_{j=1}^{c}q_L^j]^2+q_0, \end{aligned}$$

Constrained by the budget[15], the representative consumer's demand func-

[14] Shimomura and Thisse (2012) also assume a similar market structure based on the CES utility function.

[15] The budget of the representative consumer is $\int_0^N p_S(i)q_S(i)di+\sum_{j=1}^{M}p_j^Lq_j^L+q_0=I$. I is

tions for big and small firms' products are:

$$p_L^j = \alpha - (\beta - \gamma)q_L^j - \gamma(Q_S + Q_L) \qquad j = 1, 2, \cdots M, \tag{4 .1}$$

$$p_S(i) = \alpha - (\beta - \gamma)q_S(i) - \gamma(Q_S + Q_L) \qquad i \in [0, N]. \tag{4 .2}$$

where p_L^j is the price of big firm j, $p_S(i)$ is the price of small firm i, $Q_L = \sum_{j=1}^{M} q_j^L$ and $Q_S = \int_0^N q_S(i)di$.

Firms' behavior

Firms compete in the Cournot manner. Imposing a non-negligible impact on the market, each big firm not only takes into account how its production affects its own price, but also estimates its impact on the behavior of other firms. Small firms are negligible so that each small firm only considers the impact of its production on its own price. Besides, small firms freely enter or exit from the market. The way we differentiate these two types of firms is in line with Kokovin et al. (2011), Shimomura and Thisse (2012) and Pan and Hanazono (2015).

Big firms

Each big firm incurs a constant marginal cost c and a fixed cost F_L. The profit function of big firm j is:

$$\Pi_L^j = (p_L^j - c)q_L^j - F_L,$$

By equation (4.1),

$$\Pi_L^j = (\alpha - c)q_L^j - (\beta - \gamma)(q_L^j)^2 - \gamma(Q_S + Q_L)q_L^j - F_L, \tag{4 .3}$$

Taking $Q_S + Q_L^{-j}$ $(Q_L^{-j} = \sum_{i \neq j}^{M} q_i^L)$ as given, big firm j chooses q_L^j to maximize Π_L^j. The firm is big or influential because it can influence Q_L by varying q_L^j.

Small firms

Each small firm incurs the same constant marginal cost c and a fixed cost F_S. The profit function of each small firm is:

$$\Pi_S(i) = (p_S(i) - c)q_S(i) - F_S,$$

the exogenously given income level.

By equation (4.2):

$$\Pi_S(i) = (\alpha - c)q_S(i) - (\beta - \gamma)(q_S(i))^2 - \gamma(Q_S + Q_L)q_S(i) - F_S, \qquad (4\cdot4)$$

Because its impact on the market is negligible, small firm i takes $Q_S + Q_L$ as given when it maximizes $\Pi_S(i)$ with respect to $q_S(i)$. In other words, $q_S(i)$ has a negligible impact on Q_S.

The free entry condition implies:

$$\Pi_S(i) = 0. \qquad (4\cdot5)$$

We assume that big and small firms move simultaneously. In the following analysis, we focus on how the merger of two big firms with product choice influences the other big firms' output levels, the market competitive fringe (the size of small firms), consumer surplus and social welfare. Hence, we only present these results concerning our central issues.

For the coexistence of the big and small firm before and after the merger, the following conditions should hold throughout the paper (See **Appendix 4-E**):

$$\alpha > 2\sqrt{(\beta - \gamma)F_S}[1 + \gamma/\beta + (M-2)\gamma/(2\beta - \gamma)] + (1 + \gamma/\beta)c,$$
$$4\beta(\beta - \gamma)F_S > (2\beta - \gamma)^2 F_L.$$

The first condition, which guarantees the existence of small firms, implies that the market size should be sufficiently large. The second condition ensures that big firms earn positive profits.[16]

4.3 Results

Before the merger

[16] We derive such a condition by assuming that all the variables are positive in our model.

The equilibrium results before merger are:

$$q_L^* = \frac{2\sqrt{F_S(\beta-\gamma)}}{2\beta-\gamma},$$

$$q_S^* = \sqrt{\frac{F_S}{\beta-\gamma}},$$

$$N^* = \frac{(\alpha-c)\sqrt{\beta-\gamma}}{\gamma\sqrt{F_S}} - \frac{2(\beta-\gamma)[2\beta+\gamma(M-1)]}{\gamma(2\beta-\gamma)},$$

$$\Pi_L^* = \frac{4\beta(\beta-\gamma)}{(2\beta-\gamma)^2}F_S - F_L,$$

$$CS = \frac{(\alpha-c)\sqrt{F_S(\beta-\gamma)} - 2F_S(\beta-\gamma)}{2\gamma} - \frac{\gamma(\beta-\gamma)M}{(2\beta-\gamma)^2}F_S,$$

$$SW = \frac{(\alpha-c)\sqrt{F_S(\beta-\gamma)} - 2F_S(\beta-\gamma)}{2\gamma} + \frac{(\beta-\gamma)(4\beta-\gamma M)}{(2\beta-\gamma)^2}F_S - F_L.$$

The above results show that in such a mixed market, big and small firms' product levels as well as big firms' profit are only determined by the firms' fixed costs and product substitutability. Only the competitive fringe N^* is related to the marginal cost and the number of incumbent big firms.

After the merger

After two big firms merge, the total number of big firms is $M-1$. The merged firm (insider) chooses between continuing to produce two types of goods or withdrawing a brand. The insider enjoys a marginal cost synergy, hence the marginal cost is reduced to λc, with $0 < \lambda < 1$. Therefore, $(1-\lambda)c$ represents the marginal cost synergy after merger. In addition, if the insider withdraws a brand, it can save a fixed cost F_L of producing that brand, such as advertising cost and distribution cost. Therefore, the insider faces a trade-off between the fixed cost saving from withdrawing one brand and the differentiation benefit of producing two brands.

To save the space, in the following part, we directly present our findings. The derivation process is available upon request.

The following proposition shows the profitability of merger with the consideration of product choice. Here "profitability" has two implications. The first is the avoidance of the merger paradox, namely, the profit of the merged big firm is larger than the sum of the profits earned by the two merging big firms ex ante. The second implication is whether it is more profitable to choose one brand or two brands.

Proposition 4.1 *(i) if* $\underline{\delta} < (1-\lambda)c < \delta_1$*, it is profitable for the merged firm to produce one type of good; (ii) if* $(1-\lambda)c > \delta_1$*, it is more profitable for the merged firm to produce two types of good.*

Here $\underline{\delta} = \sqrt{8F_S(\beta-\gamma) - F_L(2\beta-\gamma)^2/\beta} - 2\sqrt{F_S(\beta-\gamma)}$ *is the smallest marginal cost synergy to avoid the merger paradox, and* $\delta_1 = \beta(2\beta-\gamma)\sqrt{2F_L/(2\beta+\gamma)}/(\beta-\gamma) - 2\sqrt{F_S(\beta-\gamma)}$ *is the smallest marginal cost synergy for the insider to supply two types of goods.*[17]

Proof. See **Appendix 4-B**. ■

Proposition 4.1 indicates when the fixed cost synergy is strong relative to the marginal cost synergy, the merged firm chooses to produce one brand because the saving on fixed cost dominates the loss of profits earned by producing another brand. However, when the marginal cost synergy is relatively strong, the opposite occurs.

On condition (i) of Proposition 4.1, we summarize the post-merger impacts when the merged firm chooses to produce one brand in Proposition 4.2.

Proposition 4.2 *If the insider chooses to produce one brand after merger, then compared with the equilibrium results before the merger:*

(i) the outputs of each non-merging big firm and small firm do not change;

(ii) the competitive fringe expands;

(iii) both consumer welfare and social welfare rise.

Proof. See **Appendix 4-C**. ■

The intuition of Proposition 4.2 can be briefly stated as follows. When the merged firm chooses to supply one brand due to high fixed cost savings,

[17] For some parameter values, it is possible that $\underline{\delta} > \delta_1$. In this case, the merged firm will always produce two types of goods. In this paper we focus on the case when $\underline{\delta} < \delta_1$.

it produces less than the sum of the two merging firms' outputs before the merger, leaving more market for other firms. A direct consequence is that more small firms enter the market, leading to an expansion of the competitive fringe. Besides, due to the buffering effect from the free entry of exit of small firms, the total output of the differentiated good market does not change, which then leaves the output of each non-merging big firm unchanged. Finally, although the withdrawal of a brand by the insider results in the loss of a variety, the expansion of the competitive fringe mitigates this loss and consumers benefit from it eventually. Because the profit of the outsiders does not change and the profit of the insider increases, social welfare also improves.

On condition (ii) of Proposition 4.1, Proposition 4.3 shows the impacts of merger when the merged firm chooses to produce two brands.

Proposition 4.3 *If the merged big firm chooses to produce two brands, then compared with ex ante merger:*

(i) the outputs of each non-merging big firm and small firm are unchanged;

(ii) if $\delta_1 < (1-\lambda)c < \delta_2$*, the competitive fringe expands, and if* $c(1-\lambda) > \delta_2$*, the competitive fringe shrinks;*

(iii) if $\delta_1 < (1-\lambda)c < \delta_3$*, consumer welfare falls and social welfare improves, if* $\delta_3 < (1-\lambda)c < \delta_2$*, both consumer welfare and social welfare deteriorate, and if* $c(1-\lambda) > \delta_2$*, both consumer welfare and social welfare improve.*

Here $\delta_2 = 2\gamma\sqrt{F_S(\beta-\gamma)}/(2\beta-\gamma)$ *is the smallest marginal cost synergy to reduce the size of small firms, and* $\delta_3 = [\sqrt{100\beta^4 - 8\beta^3\gamma - 23\beta^2\gamma^2 + 2\beta\gamma^3 + 2\gamma^4} - (2\beta-\gamma)(5\beta+2\gamma)]\sqrt{F_S(\beta-\gamma)}/[(2\beta-\gamma)(3\beta+\gamma)]$ *is the smallest marginal cost synergy to improve social welfare.*

Proof. See **Appendix 4-D**. ■

As shown by Proposition 4.3, when the insider chooses to produce two brands after merger, moderate cost synergy is not beneficial to consumer welfare even though it induces the entry of small firms. This implies that the increase in market power of the merged firm by internalization dominates the marginal cost synergy, thus deteriorating consumer welfare. If the cost synergy is very large, the efficiency gain outweighs the internalization, and consumer welfare improves even if fewer small firms survive. The condition for improving social welfare is weaker than that for increasing consumer welfare because firms' total profits rise after merger.

From Propositions 4.2 and 4.3, we conclude that in the market where big firms and small firms coexist, neither merger nor post-merger product choice exert any impact on other big firms' output level. That is because the small firms' entry or exit fully buffers the market aggregate output fluctuation brought by the merged big firm's product choice. More importantly, the merged firm's different product choices play a central role in determining the impacts of merger on the competitive fringe and social welfare.

4.4 Discussion

Here, we would like to briefly compare some literature to the present paper. First, in contrast to the canonical wisdom that outsiders free ride from merger in Cournot competition, we show that the non-merging big firms are not affected, owing to the buffering effect of small firms. Neither has the competitive fringe been investigated by existing merger literature. Second, different from Lommerud and Sorgard (1997), who show that the withdrawal of a brand by the insider generates an ambiguous effect on consumer welfare, we find that such a post-merger product choice raises consumer welfare because of the induced entry of small firms, which is not considered in their paper. We also find similar results when the quadratic marginal cost is considered.

In summary, this paper attempts to deepen our understanding of merger in the market with the coexistence of big and small firms. More work can be done in future.

4.5 Appendices

Appendix 4-A The equilibrium results before the merger

The profit function of each small firm is:

$$\begin{aligned}\Pi_S(i) &= (p_S(i)-c)q_S(i)-F_S \\ &= (\alpha-c)q_S(i)-(\beta-\gamma)(q_S(i))^2-\gamma(Q_S+Q_L)q_S(i)-F_S. \quad (4\ .6)\end{aligned}$$

A small firm only accounts for the impact of the market's total production, but its impact on the market is negligible. Hence the small firm's profit maximization with respect to $q_S(i)$ yields the optimal quantity produced by each small firm in terms of the size of small firms N and total output of big firms Q_L:

$$q_S(N, Q_L) = \frac{\alpha-c-\gamma Q_L}{2(\beta-\gamma)+\gamma N}.$$

In addition, the free entry condition for small firms is:

$$[\alpha-c-(\beta-\gamma+\gamma N)q_S-\gamma Q_L]q_S-F_S=0. \quad (4\ .7)$$

Hence, we can obtain the optimal quantity q_S^* and size of small firms N^* in terms of the total output of big firms Q_L:

$$q_S^* = \sqrt{\frac{F_S}{\beta-\gamma}},$$

$$N^*(Q_L) = \frac{1}{\gamma}[\sqrt{\frac{\beta-\gamma}{F_S}}(\alpha-c-\gamma Q_L)-2(\beta-\gamma)]. \quad (4\ .8)$$

The profit function of a big firm is:

$$\begin{aligned}\Pi_L^j &= (p_L^j-c)q_L^j-F_L \\ &= (\alpha-c)p_L^j-(\beta-\gamma)(q_L^j)^2-\gamma(Q_S+Q_L)q_L^j-F_L. \quad (4\ .9)\end{aligned}$$

Big firm j's profit maximization with respect to q_L^j yields its optimal output in terms of the total output of small firms Q_S and the total output of other big firms Q_L^{-j}:

$$q_L^{j*}(Q_S, Q_L^{-j}) = \frac{\alpha-c-\gamma Q_S-\gamma Q_L^{-j}}{2\beta},$$

Since the big firms are symmetric, $q_L^{j*} = q_L^*$, and $Q_L^* = Mq_L^*$. Hence the optimal output of each big firm can be expressed as

$$q_L^*(N) = \frac{\alpha - c - \gamma N q_S}{2\beta + \gamma(M-1)}, \tag{4 .10}$$

Equations (4.8) and (4.10) yield the number of small firms and optimal output of each big firm in equilibrium:

$$N^* = \frac{(\alpha - c)\sqrt{\beta - \gamma}}{\gamma\sqrt{F_S}} - \frac{2(\beta-\gamma)[2\beta + \gamma(M-1)]}{\gamma(2\beta - \gamma)},$$
$$q_L^* = \frac{2\sqrt{F_S(\beta-\gamma)}}{2\beta - \gamma}.$$

And the total quantity of the differentiated good is:

$$Q^* = \frac{\alpha - c - 2\sqrt{F_S(\beta-\gamma)}}{\gamma}.$$

The prices of the small firm and the big firm are respectively:

$$p_S^* = \alpha - (\beta - \gamma)q_S^* - \gamma Q^* = c + \sqrt{(\beta-\gamma)F_S},$$
$$p_L^* = \alpha - (\beta - \gamma)q_L^* - \gamma Q^* = c + \frac{2\beta}{2\beta - \gamma}\sqrt{(\beta-\gamma)F_S}.$$

The profit of the small firm is zero, and the profit of the big firm is:

$$\Pi_L^* = (p_L^* - c)q_L^* - F_L = \frac{4\beta(\beta-\gamma)}{(2\beta-\gamma)^2}F_S - F_L.$$

Substituting q_S^*, N^*, q_L^*, Q^*, p_S^* and p_L^*, the consumer surplus is:

$$\begin{aligned} CS &= U - I \\ &= \frac{(\alpha - c)\sqrt{F_S(\beta-\gamma)} - 2F_S(\beta-\gamma)}{2\gamma} - \frac{\gamma(\beta-\gamma)M}{(2\beta-\gamma)^2}F_S. \end{aligned}$$

And social welfare is:

$$\begin{aligned} SW &= CS + M\Pi_L^* \\ &= \frac{(\alpha - c)\sqrt{F_S(\beta-\gamma)} - 2F_S(\beta-\gamma)}{2\gamma} + \frac{(\beta-\gamma)(4\beta - \gamma M)}{(2\beta-\gamma)^2}F_S - F_L. \end{aligned}$$

Appendix 4-B Proof of Proposition 4.1

In the following proof, we denote the variables with a superscript of 1 in the case when the merged firm produces one type of product, and denote the variables with a superscript of 2 in the case when the merged firm produces two types of products.

If the merged firm produces one type of product, the inverse demand functions for the insider, outsiders and small firms are respectively:

$$p_I^1 = \alpha - (\beta-\gamma)q_I^1 - \gamma(Q_S^1 + q_I^1 + \sum_{k=1}^{M-1} q_{Ok}^1), \tag{4 .11}$$

$$p_O^1 = \alpha - (\beta-\gamma)q_{Oj}^1 - \gamma(Q_S^1 + q_I^1 + q_{Oj}^1 + \sum_{k\neq j} q_{Ok}^1), \tag{4 .12}$$

$$p^1(i) = \alpha - (\beta-\gamma)q(i) - \gamma(Q_S^1 + q_I^1 + \sum_{k=1}^{M-1} q_{Ok}^1) \qquad i \in [0, N]. \tag{4 .13}$$

The merged firm enjoys a cost synergy, hence the marginal cost is reduced to λc, where $0 < \lambda < 1$. In addition, the merged firm also enjoys a fixed cost synergy of F_L by withdrawing a brand. The profit functions of the three types of firms are:

$$\begin{aligned}
\Pi_I^1 &= (p_I^1 - \lambda c)q_I^1 - F_L \\
&= (\alpha - \lambda c)q_I^1 - (\beta-\gamma)(q_I^1)^2 - \gamma(Q_S^1 + q_I^1 + \sum_{k=1}^{M-1} q_{Ok}^1)q_I^1 - F_L, \\
\Pi_O^1 &= (p_O^1 - c)q_O^1 - F_L \\
&= (\alpha - c)q_O^1 - (\beta-\gamma)(q_O^1)^2 - \gamma(Q_S^1 + q_I^1 + \sum_{k=1}^{M-1} q_{Ok}^1)q_O^1 - F_L, \\
\Pi_S^1(i) &= (p^1(i) - c)q^1(i) - F_S \\
&= (\alpha - c)q^1(i) - (\beta-\gamma)(q^1(i))^2 - \gamma(Q_S^1 + q_I^1 + \sum_{k=1}^{M-1} q_{Ok}^1)q^1(i) - F_S.
\end{aligned}$$

First order conditions with respect to the quantities of each type of firm and zero profit condition of small firms yield the optimal outputs and number of small firms:

$$q_I^{1*} = \frac{2\sqrt{F_S(\beta-\gamma)} + c(1-\lambda)}{2\beta-\gamma},$$
$$q_O^{1*} = \frac{2\sqrt{F_S(\beta-\gamma)}}{2\beta-\gamma},$$
$$q_S^{1*} = \sqrt{\frac{F_S}{\beta-\gamma}},$$
$$N^{1*} = \frac{(\alpha-c)\sqrt{\beta-\gamma}}{\gamma\sqrt{F_S}} - \frac{2(\beta-\gamma)[2\beta+\gamma(M-2)]}{\gamma(2\beta-\gamma)} - \frac{(1-\lambda)c}{2\beta-\gamma}\sqrt{\frac{\beta-\gamma}{F_S}}.$$

The total output in equilibrium is:

$$Q^{1*} = N^{1*}q_S^{1*} + q_I^{1*} + (M-2)q_O^{1*} = \frac{\alpha - c - 2\sqrt{F_S(\beta-\gamma)}}{\gamma}.$$

The prices of each type of firm are:

$$p_S^{1*} = \alpha - (\beta-\gamma)q_S^{1*} - \gamma Q^{1*} = c + \sqrt{(\beta-\gamma)F_S},$$
$$p_I^{1*} = \alpha - (\beta-\gamma)q_I^{1*} - \gamma Q^{1*} = c\frac{\beta+\lambda(\beta-\gamma)}{2\beta-\gamma} + \frac{2\beta}{2\beta-\gamma}\sqrt{(\beta-\gamma)F_S},$$
$$p_O^{1*} = \alpha - (\beta-\gamma)q_O^{1*} - \gamma Q^{1*} = c + \frac{2\beta}{2\beta-\gamma}\sqrt{(\beta-\gamma)F_S}.$$

And the profits are:

$$\Pi_S^{1*} = \Pi_S^* = 0,$$
$$\Pi_O^{1*} = \Pi_L^* = \frac{4\beta(\beta-\gamma)}{(2\beta-\gamma)^2}F_S - F_L,$$
$$\Pi_I^{1*} = (p_I^{M*} - \lambda c)q_I^{M*} - F_L = \frac{\beta[2\sqrt{F_S(\beta-\gamma)} + c(1-\lambda)]^2}{(2\beta-\gamma)^2} - F_L.$$

Merger is profitable if $\Pi_I^{1*} > 2\Pi_L^*$, i.e. $c(1-\lambda) > \underline{\delta}$,
where $\underline{\delta} = \sqrt{8F_S(\beta-\gamma) - F_L(2\beta-\gamma)^2/\beta} - 2\sqrt{F_S(\beta-\gamma)}$.
If the merged firm produces two types of products, the inverse demand

functions for the insider, outsiders and small firms are respectively:

$$p_I^2 = \alpha - (\beta - \gamma)q_I^2 - \gamma(Q_S^2 + 2q_I^2 + \sum_{k=1}^{M-1} q_{Ok}^2),$$

$$p_O^2 = \alpha - (\beta - \gamma)q_{Oj}^2 - \gamma(Q_S^2 + 2q_I^2 + q_{Oj}^2 + \sum_{k\neq j}^{M-1} q_{Ok}^2),$$

$$p^2(i) = \alpha - (\beta - \gamma)q^2(i) - \gamma(Q_S^2 + 2q_I^2 + \sum_{k=1}^{M-1} q_{Ok}^2) \qquad i \in [0, N].$$

where q_I^2 is the output of each variety produced by the merged firm.

Producing two types of products, the merged firm only enjoys a cost synergy, with the marginal cost being reduced to λc, where $0 < \lambda < 1$. The profit functions of the three types of firms are:

$$\begin{aligned}
\Pi_I^2 &= 2(p_I^2 - \lambda c)q_I^2 - 2F_L \\
&= (\alpha - \lambda c)q_I^2 - (\beta - \gamma)(q_I^2)^2 - \gamma(Q_S^2 + 2q_I^2 + \sum_{k=1}^{M-1} q_{Ok}^1)q_I^1 - 2F_L, \\
\Pi_O^2 &= (p_O^2 - c)q_O^2 - F_L \\
&= (\alpha - c)q_O^2 - (\beta - \gamma)(q_O^2)^2 - \gamma(Q_S^2 + 2q_I^2 + \sum_{k=1}^{M-1} q_{Ok}^2)q_O^2 - F_L, \\
\Pi_S^2(i) &= (p^2(i) - c)q^2(i) - F_S \\
&= (\alpha - c)q^2(i) - (\beta - \gamma)(q^2(i))^2 - \gamma(Q_S^2 + 2q_I^2 + \sum_{k=1}^{M-1} q_{Ok}^2)q^2(i) - F_S.
\end{aligned}$$

First order conditions with respect to the quantities of each type of firm and zero profit condition of small firms yield the optimal outputs and number of small firms:

$$q_I^{2*} = \frac{2\sqrt{F_S(\beta - \gamma)} + c(1 - \lambda)}{2\beta},$$

$$q_O^{2*} = \frac{2\sqrt{F_S(\beta - \gamma)}}{2\beta - \gamma},$$

$$q_S^{2*} = \sqrt{\frac{F_S}{\beta - \gamma}},$$

$$N^{2*} = \frac{(\alpha - c)\sqrt{\beta - \gamma}}{\gamma\sqrt{F_S}} - \frac{2(\beta - \gamma)[2\beta^2 + \beta\gamma(M - 1) - \gamma^2]}{\beta\gamma(2\beta - \gamma)} - \frac{(1 - \lambda)c}{\beta}\sqrt{\frac{\beta - \gamma}{F_S}}.$$

The total output is:

$$Q^{2*} = Q_S^{2*} + 2q_I^{2*} + Q_O^{2*} = \frac{\alpha - c - 2\sqrt{F_S(\beta-\gamma)}}{\gamma}.$$

So the total output is not changed after merger.

The prices of each type of firm are:

$$p_S^{2*} = \alpha - (\beta-\gamma)q_S^{2*} - \gamma Q^{2*} = c + \sqrt{(\beta-\gamma)F_S},$$
$$p_I^{2*} = \alpha - (\beta-\gamma)q_I^{2*} - \gamma Q^{2*} = c\frac{\beta+\gamma+\lambda(\beta-\gamma)}{2\beta} + \frac{\beta+\gamma}{\beta}\sqrt{(\beta-\gamma)F_S},$$
$$p_O^{2*} = \alpha - (\beta-\gamma)q_O^{2*} - \gamma Q^{2*} = c + \frac{2\beta}{2\beta-\gamma}\sqrt{(\beta-\gamma)F_S}.$$

And the profits are:

$$\Pi_S^{2*} = \Pi_S^* = 0,$$
$$\Pi_O^{2*} = \Pi_L^* = \frac{4\beta(\beta-\gamma)}{(2\beta-\gamma)^2}F_S - F_L,$$
$$\Pi_I^{2*} = 2(p_I^{2*} - \lambda c)q_I^{2*} - 2F_L = \frac{(\beta+\gamma)[2\sqrt{(\beta-\gamma)F_S} + c(1-\lambda)]^2}{2\beta^2} - 2F_L.$$

Now we compare Π_I^{1*} and Π_I^{2*}. We can derive that $\Pi_I^{1*} < \Pi_I^{2*}$ if $(1-\lambda)c > \delta_1$, and $\Pi_I^{1*} > \Pi_I^{2*}$ if $(1-\lambda)c < \delta_1$, where $\delta_1 = \beta(2\beta-\gamma)\sqrt{2F_L/(2\beta+\gamma)}/(\beta-\gamma) - 2\sqrt{F_S(\beta-\gamma)}$.

This establishes Proposition 4.1.

Appendix 4-C Proof of Proposition 4.2

From the results derived in **Appendix 4-B**, we can directly get the first argument.

The difference between N^{1*} and N^* is:

$$N^{1*} - N^* = \frac{2(\beta-\gamma)}{2\beta-\gamma} - \frac{(1-\lambda)c}{2\beta-\gamma}\sqrt{\frac{\beta-\gamma}{F_S}}.$$

which is positive if $(1-\lambda)c < 2\sqrt{F_S(\beta-\gamma)}$. Since $\delta_1 < 2\sqrt{F_S(\beta-\gamma)}$ always holds, the condition for $\Pi_I^{1*} > \Pi_I^{2*}$ is sufficient for the condition for $N^{1*} > N^*$.

Therefore, the competitive fringe always expands when the merged firm chooses to produce one type of product. This establishes the second argument.

The difference between CS^1 and CS is:

$$\begin{aligned} CS^1 - CS &= \alpha(Q^{1*} - Q^*) - \frac{\beta-\gamma}{2}[N^{1*}(q_S^{1*})^2 - N^*(q_S^*)^2 + (q_I^{1*})^2 \\ &\quad +(M-2)(q_O^{1*})^2 - M(q_L^*)^2] - \frac{\gamma}{2}[(Q^{1*})^2 - (Q^*)^2] \\ &= \frac{1}{2(2\beta-\gamma)^2}[2\sqrt{F_S(\beta-\gamma)} - (1-\lambda)c] \\ &\quad [\gamma\sqrt{F_S(\beta-\gamma)} + (\beta-\gamma)(1-\lambda)c] + 2(\beta-\gamma)[(1-\lambda)c]^2. \end{aligned}$$

which is always positive when $(1-\lambda)c < 2\sqrt{F_S(\beta-\gamma)}$, the same condition for the expansion of the competitive fringe. Therefore, consumer welfare improves.

Because the merged firm earns more profits, and the non-merging firms are not affected, the total profits of firms increase. As a result, social welfare also improves. The third argument is established.

Appendix 4-D Proof of Proposition 4.3

From he results derived in **Appendix 4-B**, The first argument is straightforward.

The difference between N^{2*} and N^* is:

$$N^{2*} - N^* = \frac{4(\beta-\gamma)}{2\beta-\gamma} - \frac{2(\beta-\gamma)}{\beta} - \frac{(1-\lambda)c}{\beta}\sqrt{\frac{\beta-\gamma}{F_S}}.$$

which is positive if $(1-\lambda)c < \delta_2$, where $\delta_2 = 2\gamma\sqrt{F_S(\beta-\gamma)}/(2\beta-\gamma)$. Therefore, the competitive fringe expands if $\delta_1 < (1-\lambda)c < \delta_2$, and shrinks if $(1-\lambda)c > \delta_2$. This establishes the second argument.

The difference between CS^2 and CS is:

$$\begin{aligned} CS^2 - CS &= \frac{1}{4\beta^2(2\beta-\gamma)^2}[(2\beta-\gamma)(1-\lambda)c - 2\gamma\sqrt{F_S(\beta-\gamma)}] \\ &\quad [(2\beta-\gamma)(\beta-\gamma)(1-\lambda)c + 2\sqrt{F_S(\beta-\gamma)}(2\beta^2 - 4\beta\gamma + \gamma^2)]. \end{aligned}$$

which is positive if $(1-\lambda)c > \delta_2$. Therefore, consumer welfare improves if $(1-\lambda)c > \delta_2$, and deteriorates if $\delta_1 < (1-\lambda)c < \delta_2$.

The difference between SW^2 and SW is:

$$\begin{aligned} SW^2 - SW &= CS^2 - CS + \Pi_I^{2*} - 2\Pi_I^* \\ &= \frac{1}{4\beta^2(2\beta-\gamma)^2}\{[(2\beta-\gamma)(1-\lambda)c - 2\gamma\sqrt{F_S(\beta-\gamma)}] \\ &\quad [(2\beta-\gamma)(3\beta+\gamma)(1-\lambda)c + 2\sqrt{F_S(\beta-\gamma)}(2\beta^2+2\beta\gamma-\gamma^2)] \\ &\quad +16\beta^2(2\beta-\gamma)(1-\lambda)c\sqrt{F_S(\beta-\gamma)}\}. \end{aligned}$$

which is positive if $(1-\lambda)c > \delta_3$, where $\delta_3 = [\sqrt{100\beta^4 - 8\beta^3\gamma - 23\beta^2\gamma^2 + 2\beta\gamma^3 + 2\gamma^4} - (2\beta-\gamma)(5\beta+2\gamma)]\sqrt{F_S(\beta-\gamma)}/[(2\beta-\gamma)(3\beta+\gamma)]$. Therefore, social welfare improves if $(1-\lambda)c > \delta_3$, and deteriorates if $(1-\lambda)c < \delta_3$. Because $\delta_3 < \delta_2$, the third argument is established.

Appendix 4-E Proof of conditions for the coexistence of big and small firms

First, we identify the condition for the existence of small firms. The smallest size of small firms is N^{2*} when $\lambda = 0$. In this extreme case, the merged firm reduces its marginal cost to zero, leading to the largest shrinkage of the competitive fringe. If the competitive fringe is positive in this case, we can guarantee the existence of small firm. Substituting $\lambda = 0$ into N^{2*}, we have:

$$N^{2*}\big|_{\lambda=0} = [\frac{\alpha-c}{\gamma} - 2\sqrt{F_S(\beta-\gamma)}(\frac{1}{\beta}+\frac{1}{\gamma}+\frac{M-2}{2\beta-\gamma}) - \frac{c}{\beta}]\sqrt{\frac{\beta-\gamma}{F_S}}.$$

which is positive if $\alpha > 2\sqrt{(\beta-\gamma)F_S}[1+\gamma/\beta+(M-2)\gamma/(2\beta-\gamma)]+(1+\gamma/\beta)c$. This establishes the first condition.

Now we identify the condition for the existence of big firms. Since the merged firm earns more profit, and the non-merging firms' profits do not change, it suffices to find the condition for the pre-merger big firm's profit to be positive:

$$\Pi_L^* = \frac{4\beta(\beta-\gamma)}{(2\beta-\gamma)^2}F_S - F_L > 0.$$

which is equivalent to $4\beta(\beta - \gamma)F_S > (2\beta - \gamma)^2 F_L$. This establishes the second condition.

5 Education Investment, Skilled–unskilled Wage Inequality and Economic Development: A Vertical Market Structure

5.1 Introduction

We are living in the era of economic integration. Economic and trade liberation brings enormous benefits, with countries having more development opportunities and people enjoying more various choices of consumption, education and work. However, globalization is a double-edge sword, as evidenced by the growing skilled-unskilled wage inequality in many developing countries during the past several decades. Empirical studies - typically exemplified by Robbins (1996), Feenstra and Hanson (1996), Wood (1997), Khan (1998), Feenstra and Hanson (2003), Lam and Liu (2011) and Mehta and Hasan (2012) - show that the increasing skilled-unskilled wage gap has prevailed in Latin American countries and some Asian countries.

This widened skilled-unskilled wage inequality in developing countries has captured the attention of many theoretical economists. Their efforts to explain it theoretically can be roughly divided into three categories. The first category of research tries to analyze the widening skilled-unskilled wage gap by considering the international factor mobility, trade liberalization and the change of production patterns. Literature representative of this approach includes Das (2002), Marjit et al (2004), Kar and Beladi (2004), Marjit and Kar (2005), Anwar (2006), Chaudhuri and Yabuuchi (2007), Beladi et al (2008), Beladi et al (2010), Gupta and Dutta (2010) Beladi et al (2011), and Pan and Zhou (2013) etc. Scholars in this category argue that investment liberation, international factor mobility and global outsourcing would increase (or conditionally increase) the wage gap between skilled labor and unskilled labor. Research in the second category argues that the growing wage inequality in developing countries can be (partially) attributed to the sector-biased or factor-biased technological progress and international technological spillover effects. The representative literature in this strand can be referred to Xu (2001), Ethier (2005), Moore and Ranjan (2005), Fang et al (2008) and Wang et al (2009) etc. Researchers in the third category explore the institutional reasons for the widened skilled-unskilled wage inequality. They contend that such institutional changes as the reduction of corrupt behaviors, deunionization and industrial adjustments are the main institutional sources of the widening wage gap. Literature in this strand can be represented by DiNardo et al (1996), Kar and Khasnobis (2006), Chaudhuri and Yabuuchi (2007), Yabuuchi and Chaudhuri (2009) and Mandal and Marjit (2010).

However, the role of education in determining skilled-unskilled wage inequality has received little attention. Nowadays, education is becoming increasingly important to a country's well-being. A higher level of education potentially stimulates a country's economic growth and enables a country to participate in the knowledge-based world economy. Yet recent research shows that some developing countries have been suffering from a shortage of skilled labor, which is a serious obstacle preventing them from gaining benefits from trade division and global disintegrated production (Yabuuchi and Chaudhuri, 2009; Beladi et al 2011). Therefore, raising the level of education and stimulating the formation of a skilled labor force should be placed among the top priorities in developing economies. Fortunately, the governments of some developing countries have started education and training projects in order to ease the shortage of skilled labor and boost economic development. For instance, the government of India has initiated a national mission of developing skills (Yabuuchi and Chaudhuri, 2009). The Chinese government has also made policies and conducted relevant pilot projects, such as the Sunshine Project, in an effort to increase the human capital of rural labor and facilitate rural-urban labor migration by training the unskilled labor that mainly comprise rural residents and rural-urban migrants . Besides, as Premier Li vowed recently, Chinese government would prioritize education for years and continuously raise the investment in education to increase the number of skilled labor so that China can rely more on the talent bonuses when making use of demographic dividends . These governmental policies in reality necessitate a theoretical examination on whether government-led skill formation projects would reduce skilled-unskilled wage inequality and promote economic development.

In order to fill the current research gap and address the issues mentioned above, this paper establishes four-sector general equilibrium models to investigate the impacts of increased governmental investment in education capital on the skilled-unskilled wage inequality and economic development. The basic model, which assumes perfect competition in the producer services sector, shows that increased education capital investment from the government will unambiguously reduce skilled-unskilled wage inequality. Economic development hinges on the role of the manufacturing sector, which should occupy a sufficiently large share of national income and expand in terms of its output. However, our result shows that increased education capital from the government does not necessarily raise the manufactured output, leaving an ambiguous impact on the economic development. Only on certain conditions can government's policy of increasing education capital stimulate the manufacturing production. Thus, increased governmental investment in the education sector would conditionally promote economic development. The robustness of the basic model is substantiated by the extended model that incorporates the monopolistic competition feature in the producer services sector.

It is notable that Kar and Beladi (2004), Kar and Khasnobis (2006), Yabuuchi and Chaudhuri (2009), Gupta and Dutta (2010) and Beladi et al (2011) also take the skill formation process into account and discuss the issues related to the skilled-unskilled wage inequality. Kar and Beladi (2004) investigate the complementarity between trade and skilled emigration in the presence of skill formation when unskilled labor does not migrate. Kar and Khasnobis (2006) argue that an increase in capital inflow may result in a rise in skilled emigration when there is a skill formation sector. Yabuuchi and Chaudhuri (2009) consider the impacts of an increase in the government's financial assistance to the education sector and capital endowment on the skilled-unskilled wage gap. Gupta and Dutta (2010) analyze the effects of changes in factor endowments and tariff rates on skilled-unskilled wage inequality with the existence of an education sector. Beladi et al (2011) find that international mobility of capital may lead to the concentration of education capital and then result in a polarization between highly-skilled and unskilled labor.

The present paper is closely related to these works in the sense that we all consider the skill formation process and its impacts on wage inequality, but this paper is distinct from them in the following three aspects. First, compared with the above-mentioned studies on the skill formation process, the present paper considers a different policy instrument and derives a different mechanism of the effects on skilled-unskilled wage gap. It can be observed that the literature mentioned above just examines how international factor mobility and tax or subsidy policies influence the skilled-unskilled wage gap with the involvement of an education sector which is considered as a medium or an intermediate step. However, this paper considers a different policy instrument – the government directly increases the education capital via governmental investment – and the change of wage inequality originates from the expansion of the education sector. Second, this paper is distinguished from the existing literature for considering a different economic structure. The papers mentioned above only consider the horizontal relations among production sectors, but the present paper highlights the vertical relation between the urban sectors, a manufacturing sector and a producer services sector. Such a vertical relation of the urban sectors prevails in modern developing economies, but is neglected by Kar and Beladi (2004), Kar and Khasnobis (2006), Yabuuchi and Chaudhuri (2009), Gupta and Dutta (2010) and Beladi et al (2011). Third, in addition to investigating skilled-unskilled wage inequality, the present paper also analyzes how the governmental investment in the education sector affects economic development (measured by national income). Developing the economy is always among the priorities when the governments in developing countries make polices.

In sum, the present paper contributes to the current body of theoretical research in two aspects. First, we try to address the issue of skilled-unskilled wage inequality from the perspective of the rising governmental investment in education, a perspective that has been largely neglected in existing works on the growing skilled-unskilled wage inequality in developing economies. Second, by investigating the impacts of government's effort to promote skill formation aimed at confronting skilled-unskilled wage inequality and facilitating economic development, this paper can be treated as an extension of the existing literature concerning skill formation by considering a different government policy and studying its relevant impacts on the wage inequality and economic development.

The rest of this paper is organized as follows. In section 2, we set up a four-sector general equilibrium model with perfect competition to analyze the effects of increased education investment on skilled-unskilled wage inequality and national income. In section 3, we test the robustness of the basic model in section 2 with the assumption of monopolistic competition within the producer services sector. In section 4, concluding remarks follow.

5.2 The Model

Consider a small open economy composed of four sectors, the urban manufacturing sector, the urban producer services sector, the rural agricultural sector and the modern education sector. The manufacturing sector produces import-competing goods by employing unskilled labor and the intermediate goods supplied by the producer services sector. The producer services sector uses skilled labor and capital to produce non-traded intermediate goods. The agricultural sector utilizes unskilled labor and land to produce exportable goods. The education sector utilizes capital to train unskilled labor into skilled labor. The factor markets and the good markets are all perfectly competitive. The dualism of the labor market in developing countries is shown by the segmentation of the labor market, where unskilled workers can only work and move between the rural agricultural and the urban manufacturing sectors while skilled labor concentrate in the producer services sector. The cost functions satisfy neoclassical properties.

Before the establishment of the theoretical model, we would like to mention two points. First, the assumption that the manufacturing sector does not employ capital as the factor of production is only to emphasize the labor-intensive characteristic of the manufacturing sector in developing countries. Capital is used in the production of the producer services sector and thus, indirectly employed by the manufacturing sector. The description of the manufacturing and producer services sector here is similar to that in Marjit et al (2004) and Beladi et al (2010). Second, the modern education sector in the present paper is similar to an intermediate sector, in which unskilled labor, combined with a certain amount of capital, can be trained to be skilled labor . The capital used by the modern education sector (the education capital) is different from that used by the producer services sector (the production capital), which can be regarded as the sector-specific capital for the education sector . The present paper also assumes that the education sector is perfectly competitive, which is in accordance with the current studies like Kar and Beladi (2004), Kar and Khasnobis (2006), Yabuuchi and Chaudhuri (2009), Gupta and Dutta (2010), and Beladi et al (2011) .

The initial education capital is private, but in order to increase the amount of skilled labor in the economy, the government will increase the amount of capital available to the education sector, which can be stemmed from an increase in the public expenditure on education .

The price of the manufacturing sector is set as numeraire. The cost minimization conditions of the urban manufacturing, producer services and rural agricultural sectors are:

$$a_{LM}w_U + a_{XM}p_X = 1, \tag{5.1}$$

$$a_{SX}w_S + a_{KX}r_X = p_X, \tag{5.2}$$

$$a_{LR}w_U + a_{TR}\tau = p_R, \tag{5.3}$$

where p_X and p_R are the prices of the producer services and agricultural sectors, respectively; w_S and w_U are the wage rates of skilled labor and unskilled labor; r_X is the interest rate of the capital utilized in the producer services sector; and τ is the return rate of land. The number of unskilled labor and that of intermediate goods to produce one unit of manufacturing product are represented by a_{LM} and a_{XM}; a_{SX} and a_{KX} are the amount of skilled labor and that of capital to produce one unit of producer services good; and a_{LR} and a_{TR} are the quantity of unskilled labor and that of land to produce one unit of agricultural product.

Following the settings in Kar and Beladi (2004), Kar and Khasnobis (2006), and Beladi et al (2011), we assume that the education sector trains the unskilled labor into skilled labor with the help of education capital. Specifically:

$$a_{KS}r_S + w_U = w_S, \tag{5.4}$$

where a_{KS} denotes the capital utilized to train each labor, and r_S is the interest rate of the capital employed in the education sector.

It is worth noting that when we consider the role of skilled labor in the education sector (e.g. teachers or trainers), our findings are still consistent. Specifically, if part of the skilled labor takes part in the skill formation process at a fixed rate, that is, an average unskilled labor is matched with $\overline{a}_{SS}$ unit of skilled labor, equation (5.4) is rewritten as:

$$a_{KS}r_S + w_U = (1 - \overline{a}_{SS})w_S. \tag{5.5}$$

It is straightforward that equation (5.5) is almost the same as equation (5.4) except for a constant parameter $(1 - \overline{a}_{SS})$. Hence the result is not changed by the existence of a fixed input of skilled labor to train each unskilled labor. Obviously, we can relax the assumption that the involvement of the skilled labor in the skill formation process does not fix at a given rate. The discussion of this case only adds the mathematical complexity to the established model, but with few additional insights. It is also not difficult to verify that the situation investigated in our paper (equation (5.4)) can also be applied to the case when the teacher is regarded as a sector-specific factor. For simplicity but without generality, we employ equation (5.4) to conduct our following analysis.

The factor market-clearing conditions are:

$$a_{SX}X = S, \tag{5 .6}$$

$$a_{LM}Y_M + a_{LR}Y_R = \overline{L} - S, \tag{5 .7}$$

$$a_{KX}X = \overline{K}_X, \tag{5 .8}$$

$$a_{KS}S = \overline{K}_S, \tag{5 .9}$$

$$a_{TR}Y_R = \overline{T}, \tag{5 .10}$$

where Y_M, X and Y_R are the outputs of the urban manufacturing, producer services and rural agricultural sectors, respectively. S denotes the amount of skilled labor. $\overline{L}$, $\overline{K}_X$, and $\overline{T}$ are the labor, (production) capital and land endowments in our assumed economy. $\overline{K}_S$ denotes the capital used in the education sector[18]. The education capital mainly originates from two sources, the initial capital endowment of the education sector and the funding from the government. In reality, the governments in developing countries often directly support the development of education sectors and raise funds for the training activities. For instance, China has initiated the Sunshine Project aimed at training rural unskilled labor to gain the skills necessary for the vocations in the

[18]From the viewpoint of the static theoretical model, we ignore the consideration of the process of capital accumulation and depreciation. Here we employ the comparative static approach to investigate how the marginal change of the capital used by the education sector influences skilled-unskilled wage inequality and economic development in the initial equilibrium.

urban area[19]. As emphasized by Chinese Premier Li recently, moreover, Chinese government would make every effort to increase the proportion of skilled labor by prioritizing education for years in hopes of relying more on the talent bonuses when making use of demographic dividends. The fiscal expenditure of education in 2012 accounted for 4% of GDP (360 million RMB), which was the highest amount to date[20].

The goods market-clearing condition for the producer services sector yields:

$$a_{XM}Y_M = X, \tag{5 .11}$$

The basic model has been established. We have ten equations, which determine the equilibrium values of ten endogenous variables w_U, w_S, r_X, r_S, τ, p_X, S, Y_M, X and Y_R. The policy variable we investigate is $\overline{K}_S$. Other variables are all parameters.

Now Proposition 5.1 is established to investigate the impacts of an increase in $\overline{K}_S$ on the wage rates of skilled and unskilled labor as well as wage inequality. Here we use the relative change in the wage rates of skilled and unskilled labor to address the issue concerning the skilled-unskilled wage gap.

Proposition 5.1 *An increase in the capital employed in the education sector will increase the wage rate of unskilled labor, decrease the wage rate of skilled labor, and therefore reduce the skilled-unskilled wage inequality.*

Proof. See **Appendix 5-A**. ■

The economic mechanism of Proposition 5.1 can be explained as follows. An increase in the capital utilized in the education sector will expand the education sector, resulting in more training of unskilled labor into skilled labor and hence increasing the number of skilled labor. Given the amount of capital employed in

[19] Detailed information can be found at http://www.mingong123.com/news/52/201110 /49145e615fed8666.html.

[20] Details are available in "Education and sci-tech can boost economy", China Daily September, 2013, http://usa.chinadaily.com.cn/china/2013-09/01/content_16934860.htm.

the producer services sector, an increase in the supply of skilled labor will reduce its marginal productivity and consequently decrease its wage rate. At the same time, an increase in the supply of skilled labor would also increase the output of the producer services sector. On the other hand, given the total endowment of labor in the economy, an increase in skilled labor is accompanied by a decrease in unskilled labor. This would increase the marginal productivity of unskilled labor and hence raise their wage rate, given an increase of the intermediate goods provided by the producer services sector and a fixed amount of land. With the fall of the wage rate of skilled labor and the rise of the wage rate of unskilled labor, therefore, an increase in the capital utilized in the education sector would reduce the skilled-unskilled wage gap.

Before analyzing the impact of an increase in $\overline{K}_S$ on economic development, we first discuss how an increase in $\overline{K}_S$ affects the outputs of the agricultural sector and the manufacturing sector, which could be summarized by Lemma 5.1.

Lemma 5.1 *i. If the government invests more in the education sector, the agricultural output will decrease.*

ii. An increase in the education capital will increase (reduce) the manufactured output if

$$\frac{S}{\overline{L}-S}\frac{\theta_{LM}\theta_{SX}}{\theta_{XM}}\sigma^X_{KS} - \frac{S}{\overline{L}-S}\frac{\lambda_{XM}\theta_{LM}(\theta^2_{SX}+\theta_{KX})}{\theta_{SX}\theta_{XM}}\sigma^M_{LX} - \frac{\lambda_{LR}}{\theta_{TR}}\sigma^R_{LT}$$
$$+\frac{\lambda_{LM}}{\theta_{XM}}(\theta_{XM}-\theta_{LM}) > (<)0.$$

Proof. *See* ***Appendix 5-B.*** ■

From Proposition 5.1, we know that a rise in education capital investment by the government would increase the output of the producer services sector, which raises the marginal productivity of the unskilled labor in the manufacturing sector and increases its wage rate. Therefore, unskilled labor in rural areas will transfer to the manufacturing sector, resulting in a reduction of the agricultural output. The conditions of the change direction of the manufactured output given in Lemma 5.1 are complicated. Intuitively, however, we may observe that the change of the manufactured output depends on the weights of two impacts. The first impact is the change in the employment of unskilled labor in the manufacturing sector. When the government increases the amount of the education capital, more unskilled labor become skilled ones and the total supply of unskilled labor decreases, which may exert a negative impact on the employment of unskilled labor in the manufacturing sector. The second impact is the increase in the intermediate input used by the manufacturing sector as a result of the growing education capital, as obtained in Proposition 5.1. The rise in the outputs of the intermediate goods employed by the manufacturing sector will generate a positive impact on the manufactured output. Therefore, the final change of the manufactured output depends on which impact is dominant.

The output of the manufacturing sector would rise on the following condition: the factor substitution elasticity of the producer services sector (σ_{KS}^X) is sufficiently large and the manufacturing sector intensively employs the intermediate good produced by the producer services sector (i.e., $\theta_{XM} > \theta_{LM}$), which ensure that the intermediate good both enjoys a significant increase from the rise of skilled labor and plays a more important role in the production of manufactured goods; while the factor substitution elasticity of the manufacturing sector (σ_{LX}^M) and that of the agricultural sector (σ_{LT}^R) are relatively small, so that the decrease of unskilled labor does not exert much negative effect on the production of the manufacturing sector. To be precise, $\frac{S}{\overline{L}-S}\frac{\theta_{LM}\theta_{SX}}{\theta_{XM}}\sigma_{KS}^X - \frac{S}{\overline{L}-S}\frac{\lambda_{XM}\theta_{LM}(\theta_{SX}^2+\theta_{KX})}{\theta_{SX}\theta_{XM}}\sigma_{LX}^M - \frac{\lambda_{LR}}{\theta_{TR}}\sigma_{LT}^R + \frac{\lambda_{LM}}{\theta_{XM}}(\theta_{XM}-\theta_{LM}) > 0$. On the contrary, the output of the manufacturing sector will fall if the manufacturing sector intensively employs unskilled labor (i.e., $\theta_{XM} < \theta_{LM}$), the factor substitution elasticity of the producer services sector (σ_{KS}^X) is relatively small, and the factor substitution elasticity of the manufacturing sector (σ_{LX}^M) and that of agricultural sector (σ_{LT}^R) are relatively large, satisfying the condition that $\frac{S}{\overline{L}-S}\frac{\theta_{LM}\theta_{SX}}{\theta_{XM}}\sigma_{KS}^X - \frac{S}{\overline{L}-S}\frac{\lambda_{XM}\theta_{LM}(\theta_{SX}^2+\theta_{KX})}{\theta_{SX}\theta_{XM}}\sigma_{LX}^M - \frac{\lambda_{LR}}{\theta_{TR}}\sigma_{LT}^R + \frac{\lambda_{LM}}{\theta_{XM}}(\theta_{XM}-\theta_{LM}) < 0$.

Now we investigate the impacts of increased education capital on national income. The national income can be described by:

$$I = Y_M + p_R Y_R, \tag{5 .12}$$

From equation (5.12) and Lemma 5.1, it is not difficult to induce that the change of national income is indefinable because it is determined by both the change of the manufactured output value and that of the agricultural output value. We will use Proposition 5.2 to give a sufficient condition on which the increased education capital investment results in economic development.

Proposition 5.2 *An increase in the capital employed in the education sector will increase the national income if*

$$\frac{\varphi_U}{\varphi_R} > -\frac{\lambda_{LM}\sigma_{KK}^X/\lambda_{XM} + (SB)/(\overline{L} - S)}{C[\lambda_{LM}\sigma_{KK}^X/\lambda_{XM} + (SB)/(\overline{L} - S)] - \sigma_{KK}^X D/\lambda_{XM}},$$

$$\textit{and } \frac{S}{\overline{L} - S}\frac{\theta_{LM}\theta_{SX}}{\theta_{XM}}\sigma_{KS}^X - \frac{S}{\overline{L} - S}\frac{\lambda_{XM}\theta_{LM}(\theta_{SX}^2 + \theta_{KX})}{\theta_{SX}\theta_{XM}}\sigma_{LX}^M - \frac{\lambda_{LR}}{\theta_{TR}}\sigma_{LT}^R + \frac{\lambda_{LM}}{\theta_{XM}}(\theta_{XM} - \theta_{LM}) > 0.$$

Proof. See **Appendix 5-C**. ■

The economic explanation of Proposition 5.2 is as follows. Given the prices of the manufacturing and agricultural sectors, the change of the national income due to increased education investment is determined by the changes in the outputs of the manufacturing and agricultural sectors. From the analysis of Proposition 5.1 we know that an increase in the amount of education capital will reduce the agricultural output but conditionally increase the output value of the manufacturing sector. Hence whether national income is raised or reduced by the increase in education investment hinges on the direction of change of the two sectors' output and the shares of two sectors' production value in national income. In our context, national income may rise only when i) the manufactured output increases and ii) the share of the manufacturing sector is sufficiently large so that the gain from the expansion of the manufacturing sector can offset the loss from the shrink of the agricultural sector. The former condition can be satisfied if the intermediate good of the producer services sector is intensively employed by the manufacturing sector, the factor substitution of the producer services sector is very elastic, and the factor substitution of manufacturing sector and that of agricultural sector are relatively inelastic, as stated in Lemma 5.1. The latter condition can be satisfied if $\frac{\varphi_U}{\varphi_R} > -\frac{\lambda_{LM}\sigma_{KK}^X/\lambda_{XM}+(SB)/(\overline{L}-S)}{C[\lambda_{LM}\sigma_{KK}^X/\lambda_{XM}+(SB)/(\overline{L}-S)]-\sigma_{KK}^X D/\lambda_{XM}}$. This result indicates that the development of the manufacturing sector plays a crucial role in determining national income when the governments in developing countries plan to train unskilled labor into skilled labor.

5.3 Extension and Discussion

In this section, we will extend the basic theoretical model by considering the producer services sector featured with increasing return to scale. With the development of information network and the knowledge economy, the producer services sectors in developing countries are increasingly technology or knowledge intensive, which makes economies of scale internal to the firms in the producer services sector. Thus, it is necessary to test the robustness of the results of the basic model by considering the producer services sector with increasing return to scale.

In order to avoid the complexity and make the model more tractable, we use the explicit functions to demonstrate how an increase in will affect skilled-unskilled wage inequality and economic development. The denotations of our model with explicit functions are in the spirit of Anwar (1998) and Anwar (2010).

The production functions of the manufacturing sector and the agricultural sector are:

$$Y_M = L_M^{1-\alpha}(\sum_{j=1}^{n} x_j^{\delta})^{\alpha/\delta}, \tag{5 .13}$$

$$Y_R = L_R^{1-\beta} T^{\beta}, \tag{5 .14}$$

where L_M denotes the unskilled labor employed in the manufacturing sector, x_j is the intermediate product produced by the jth producer service enterprise, and denotes the number of producer service enterprises. L_R and T denote the unskilled labor and land used in the agricultural sector respectively. α, β and δ are parameters that all belong to $(0, 1)$. Both functions satisfy Cobb-Douglas conditions, so they are strictly quasi-concave and linearly homogeneous. The production function of equation (5.13) can be also found in Markusen (1989) and Anwar (1998).

In the producer services sector, every type of intermediate good x_j is produced by the employment of sector-specific capital and skilled labor. Here we assume that capital is the fixed input, of which each enterprise employs θ, and that skilled labor is the variable input, of which each enterprise employs L_{xj}. $L_{xj} = \lambda x_j$, which means that the jth enterprise needs to employ skilled labor of to produce one unit of good. As a result, the total cost of the jth enterprise is $C_{xj} = r_X \theta + w_S(\lambda x_j)$, where w_S is the wage rate of skilled labor employed in the producer services sector, and r_X is the interest rate of the capital utilized in the producer services sector. The denotation of the cost function of the producer services sector is in accordance with Anwar (1998) and Anwar (2010). Since each enterprise in the producer services sector has the same cost structure, the producer services sector meets the symmetric assumption, which means that all the enterprises in this sector share the same factor price, product price and level of production. Therefore, the total output of the producer services sector equals the number of enterprises in this sector times the output of each enterprise, that is, $X = nx$, where x is the output of each producer service enterprise. As a result, equation (5.13) can be simplified to:

$$Y_M = L_M^{1-\alpha} X^{\alpha} n^{\alpha(1-\delta)/\delta}, \tag{5 .15}$$

The term $n^{\alpha(1-\delta)/\delta}$, where $\alpha(1-\delta)/\delta \in (0, 1)$, describes the external economies of scale to the manufacturing sector, which is exerted by the agglomeration of the producer services enterprises (Anwar 1998; Anwar, 2010). Here we set the price of the manufactured good as numeraire.

The cost minimization condition of the manufacturing sector yields:

$$[(\frac{\alpha}{1-\alpha})^{-\alpha} + (\frac{\alpha}{1-\alpha})^{1-\alpha}] w_U^{1-\alpha} p_X^{\alpha} n^{-\alpha(1-\delta)/\delta} = 1, \tag{5 .16}$$

When the number of varieties in the producer services sector is sufficiently large, the price elasticity of demand of the manufacturing sector to each variety of good is $1/(1-\delta)$.

The profit maximization condition of the producer services sector yields:

$$w_S \lambda = \delta p_X, \tag{5 .17}$$

According to the zero profit condition of the producer services sector, we may obtain:

$$r_X \theta = (1-\delta) p_X x, \tag{5 .18}$$

The cost minimization condition of the agricultural sector yields:

$$[\beta^{-\beta}(1-\beta)^{1-\beta}] w_U^{1-\beta} \tau^{\beta} = p_R, \tag{5 .19}$$

The education sector is described in the following equation:

$$a_{KS} r_S + w_U = w_S, \tag{5 .20}$$

The market clearing conditions for skilled labor, unskilled labor, the capital of the producer services sector, the capital of the education sector and land yield:

$$n(\lambda x) = S, \tag{5 .21}$$

$$[(\frac{\alpha}{1-\alpha}\frac{w_U}{p_X} n^{(1-\delta)/\delta})^{-\alpha} Y_M + (\frac{\beta}{1-\beta}\frac{w_U}{\tau})^{-\beta} Y_R = \overline{L} - S, \tag{5 .22}$$

$$n\theta = \overline{K}_X, \tag{5 .23}$$

$$a_{KS} S = \overline{K}_E + \overline{K}_S, \tag{5 .24}$$

$$(\frac{\beta}{1-\beta}\frac{w_U}{\tau})^{1-\beta} Y_R = \overline{T}, \tag{5 .25}$$

The market clearing condition for the intermediate good provided by the producer services sector yields:

$$\alpha[(\frac{\alpha}{1-\alpha})^{-\alpha} + (\frac{\alpha}{1-\alpha})^{1-\alpha}](\frac{w_U}{p_X})^{1-\alpha} n^{-\alpha(1-\delta)/\delta} Y_M = nx, \tag{5 .26}$$

The establishment of the extended model has been completed. 11 equations, which are equations (5.16) to (5.26), determine the equilibrium value of 11 endogenous variables, which are w_U, w_S, r_X, r_S, τ, p_X, S, Y_M, X, Y_R and n. The policy variable is also $\overline{K}_S$. Other variables are all parameters.

It is not difficult to verify the robustness of the findings achieved by the basic model and now we use Proposition 5.3 to summarize how an increase in $\overline{K}_S$ influences skilled-unskilled wage inequality and economic development in the presence of the monopolistically competitive producer services sector.

Proposition 5.3 *When the producer services sector is monopolistically competitive, the impacts exerted by an increase in the education capital on the wage rates of skilled labor and unskilled labor, skilled-unskilled wage gap and economic development are almost the same as those achieved by Proposition 5.1 and Proposition 5.2.*

Proof. See **Appendix 5-D**. ■

he economic mechanism of Proposition 5.3 is similar to those shown by Proposition 5.1 and Proposition 5.2. Combining with the results achieved by the three propositions, we can conclude that whether the producer services sector is perfectly competitive or monopolistically competitive does not remarkably influence the effects of increased education capital on either the wage rates of skilled and unskilled wage rate or skilled-unskilled wage gap. Thus, we may conclude that the government in developing countries should consider increasing education capital investment as a way to address the growing skilled-unskilled wage inequality. At the same time, it stresses out again the crucial role played by the share of the manufacturing sector in facilitating economic development.

5.4 Conclusion

During the last several decades, many developing countries around the world have experienced growing skilled-unskilled wage inequality. Theoretical scholars have tried to address this issue from the perspectives of economic liberation and technological progress. However, human capital inequality is also a crucial reason for skilled-unskilled wage inequality in such developing countries as China and India, which suffer seriously from the shortage of skilled labor. The governments in these countries have made efforts to train unskilled labor into skilled labor in the hope of boosting economic development. Therefore, it is worth investigating the impacts on skilled-unskilled wage inequality and economic development from the government-led training projects .

This paper establishes two four-sector general equilibrium models to investigate the impacts of an increase in education capital investment by the government on skilled-unskilled wage inequality and economic development. In the basic theoretical model, we find that an increase in the amount of education capital investment by the government will decrease the wage rate of skilled labor and increase the wage rate of unskilled labor, resulting in a reduction of their wage gap. In this regard, the government may pay attention to the potential social conflicts and instability when implementing the education investment policy. Some actions, such as subsidies to skilled wage and tax rebates to the urban high-skill industry, may also be taken into account. In addition, the results also indicate that increased education capital investment will lead to a reallocation of the production factors and will not necessarily boost economic development. If the manufactured output value occupies a large share in the national income, and the growing education capital investment leads to the expansion of the manufacturing sector, the increase in education capital investment by the government will stimulate economic development. Therefore, we can conclude that the development level of the manufacturing sector plays a crucial role in determining economic development when the government carries out the education policy. When we extend the basic model by considering the monopolistically competitive feature of the producer services sector, the results of the basic model are predicted to be robust.

Considering different cost structures of the producer services sector, and using data or choosing some suitable values of the parameters to calibrate the theoretical model in the present paper are two possible ways for future research. All in all, this paper is just an attempt for further studies.

5.5 Appendices

Appendix 5-A: Proof of Proposition 5.1

Total differentiation of equations (5.1) to (5.11) yields:

$$\theta_{XM}\widehat{p}_X + \theta_{LM}\widehat{w}_U = 0, \tag{5 .27}$$

$$\theta_{XS}\widehat{w}_S + \theta_{KX}\widehat{r}_X = 0, \tag{5 .28}$$

$$\theta_{LR}\widehat{w}_U + \theta_{TR}\widehat{\tau} = 0, \tag{5 .29}$$

$$\theta_{KS}(w_S - w_U)\widehat{r}_S = w_S\widehat{w}_S - w_U\widehat{w}_U, \tag{5 .30}$$

$$\lambda_{SX}\widehat{X} + \lambda_{SX}\widehat{a}_{SX} = \widehat{S}, \tag{5 .31}$$

$$\lambda_{LM}\widehat{Y}_M + \lambda_{LR}\widehat{Y}_R + \lambda_{LM}\widehat{a}_{LM} + \lambda_{LR}\widehat{a}_{LR} = -\frac{S}{\overline{L} - S}\widehat{S}, \tag{5 .32}$$

$$\widehat{X} + \widehat{a}_{KX} = 0, \tag{5 .33}$$

$$\lambda_{KS}\widehat{S} + \lambda_{KS}\widehat{a}_{KS} = \widehat{\overline{K}}_S, \tag{5 .34}$$

$$\widehat{Y}_R + \widehat{a}_{TR} = 0, \tag{5 .35}$$

$$\lambda_{XM}\widehat{Y}_M + \lambda_{LM}\widehat{a}_{XM} = \widehat{X}. \tag{5 .36}$$

where θ_{ij} is the distributive share (e.g. $\theta_{SX} = a_{SX}w_S/P_X$); λ_{ij} is the allocative share (e.g. $\lambda_{LM} = a_{LM}Y_M/(\overline{L} - S)$); "$\wedge$" is the relative change of the variable (e.g. $\widehat{p}_X = dp_X/p_X$).

Equations (5.27) to (5.36) can be reduced to the following two by two equations system:

$$\begin{pmatrix} A & B \\ \lambda_{LM}(C-\sigma^M_{LX})+\lambda_{LR}(\sigma^R_{TT}-\sigma^R_{LT}) & \lambda_{LM}\sigma^X_{KK}/\lambda_{XM} \end{pmatrix} \begin{pmatrix} \widehat{w}_U \\ \widehat{w}_S \end{pmatrix}$$

$$= \begin{pmatrix} 1 \\ -S/(\overline{L}-S) \end{pmatrix} \widehat{\overline{K}}_S. \qquad (5 \cdot 37)$$

where $A = (\theta_{LM}/\theta_{XM})(\sigma^X_{KK} - \sigma^X_{SK}) < 0$, $B = \theta_{SX}\sigma^X_{KK} - \sigma^X_{SK} < 0$, and $C = \sigma^M_{XX} + \theta_{LM}\sigma^X_{KK}/\theta_{XM}\lambda_{XM} < 0$. σ^M_{ij} is the substitution elasticity of factor i and factor j of the manufacturing sector; $\sigma^X_{ij}$is the substitution elasticity of factor i and factor j of the producer services sector; and σ^R_{ij} is the substitution elasticity of factor i and factor j of the agricultural sector.

The determinant of the coefficient matrix of (5.37) is denoted as Δ, and we have:

$$\Delta = A\frac{\lambda_{LM}}{\lambda_{XM}}\sigma^X_{KK} - B[\lambda_{LM}(C-\sigma^M_{LX}) + \lambda_{LR}(\sigma^R_{TT} - \sigma^R_{LT})].$$

The sign of is indefinable. Similar to Funatsu (1988), we use the following two excess demand functions to conduct the dynamic adjustment process:

$$\dot{w}_S = d_1(a_{SX}X - S), \qquad (5 \cdot 38)$$

$$\dot{w}_U = d_2(a_{LM}Y_M + a_{LR}Y_R - (\overline{L} - S). \qquad (5 \cdot 39)$$

where $\dot{w}_S = dw_S/dt$, and $\dot{w}_U = dw_U/dt$. The positive adjustment speed are denoted by d_1 and d_2.

The Jacobian matrix of the above system is:

$$J = d_1 d_2 S(\overline{L}-S) \begin{pmatrix} B & A \\ \lambda_{LM}\sigma^X_{KK}/\lambda_{XM} & \lambda_{LM}(C-\sigma^M_{LX}) + \lambda_{LR}(\sigma^R_{TT} - \sigma^R_{LT}) \end{pmatrix}.$$

From the condition of the local stability of the above dynamic system, we must have $|J| > 0$. Thus, $\Delta < 0$.

Using the Cramer's rule to solve equation (**??**) yields:

$$\frac{\widehat{w}_U}{\widehat{\overline{K}}_S} = \frac{\lambda_{LM}\sigma^X_{KK}/\lambda_{XM} + BS/(\overline{L} - S)}{\Delta} > 0,$$

$$\frac{\widehat{w}_S}{\widehat{\overline{K}}_S} = \frac{AS/(\overline{L} - S) + B[\lambda_{LM}(C - \sigma^M_{LX}) + \lambda_{LR}(\sigma^R_{TT} - \sigma^R_{LT})]}{\Delta} < 0,$$

$$\frac{\widehat{w}_S - \widehat{w}_U}{\widehat{\overline{K}}_S} < 0.$$

Appendix 5-B: Proof of Lemma 5.1

Combining the results of Proposition 5.1 (the equilibrium value of) with equations (5.29) and (5.35) yields:

$$\frac{\widehat{Y}_R}{\widehat{\overline{K}}_S} = \frac{\sigma^R_{TT}[\lambda_{LM}\sigma^X_{KK}/\lambda_{XM} + BS/(\overline{L} - S)]}{\Delta} < 0.$$

From equation (5.36) and the equilibrium values of $\widehat{w}_U/\widehat{\overline{K}}_S$and $\widehat{w}_S/\widehat{\overline{K}}_S$, we have:

$$\frac{\widehat{Y}_M}{\widehat{\overline{K}}_S} = \frac{C\widehat{w}_U + \sigma^X_{KK}\widehat{w}_S/\lambda_{XM}}{\widehat{\overline{K}}_S} = \frac{C[\lambda_{LM}\sigma^X_{KK}/\lambda_{XM} + BS/(\overline{L} - S)] - \sigma^X_{KK}D/\lambda_{XM}}{\Delta}.$$

where $D = AS/(\overline{L} - S) + \lambda_{LM}(C - \sigma^M_{LX}) + \lambda_{LR}(\sigma^R_{TT} - \sigma^R_{LT}) < 0.$

Thus, we have $\widehat{Y}_M/\widehat{\overline{K}}_S > (<)0$ when:

$$\frac{S}{\overline{L} - S}\frac{\theta_{LM}\theta^2_{SX}}{\lambda_{XM}\theta_{XM}}\sigma^X_{KS} + \frac{\theta_{LM}\theta_{SX}}{\lambda_{XM}\theta_{XM}}(\theta_{XM} - \theta_{LM}) -$$
$$\frac{S}{\overline{L} - S}\frac{\theta_{LM}(\theta^2_{SX} + \theta_{KX})}{\theta_{XM}}\sigma^M_{LX} > (<)\frac{\lambda_{LR}\theta_{SX}}{\lambda_{XM}\theta_{TR}}\sigma^R_{LT}.$$

Appendix 5-C: Proof of Proposition 5.2

Total differentiation of equation (5.12) yields:

$$\frac{\widehat{I}}{\widehat{\overline{K}}_S} = \varphi_M\frac{\widehat{Y}_M}{\widehat{\overline{K}}_S} + \varphi_R\frac{\widehat{Y}_R}{\widehat{\overline{K}}_S}.$$

where $\varphi_M = Y_M/I$ and $\varphi_R = p_R Y_R/I$.

Combining the proof of Proposition 5.1 and Lemma 5.1, we can find that $\widehat{I}/\widehat{\overline{K}}_S > 0$ if:

$$\frac{\varphi_U}{\varphi_R} > -\frac{\lambda_{LM}\sigma_{KK}^X/\lambda_{XM} + (SB)/(\overline{L}-S)}{C[\lambda_{LM}\sigma_{KK}^X/\lambda_{XM} + (SB)/(\overline{L}-S)] - \sigma_{KK}^X D/\lambda_{XM}},$$

$$\text{and } \frac{S}{\overline{L}-S}\frac{\theta_{LM}\theta_{SX}}{\theta_{XM}}\sigma_{KS}^X - \frac{S}{\overline{L}-S}\frac{\lambda_{XM}\theta_{LM}(\theta_{SX}^2+\theta_{KX})}{\theta_{SX}\theta_{XM}}\sigma_{LX}^M$$
$$-\frac{\lambda_{LR}}{\theta_{TR}}\sigma_{LT}^R + \frac{\lambda_{LM}}{\theta_{XM}}(\theta_{XM}-\theta_{LM}) > 0.$$

Appendix 5-D: Proof of Proposition 5.3

The proof of Proposition 5.3 can be divided into three steps.

Step 1:

Total differentiation of equations (5.15) to (5.25) yields:

$$-\alpha(\frac{\delta}{1-\delta})\widehat{n} + (1-\alpha)\widehat{w}_U + \alpha\widehat{p}_X = 0, \tag{5.40}$$

$$\widehat{w}_S - \widehat{p}_X = 0, \tag{5.41}$$

$$\widehat{p}_X + \widehat{x} - \widehat{r}_X = 0, \tag{5.42}$$

$$(1-\beta)\widehat{w}_U + \beta\widehat{\tau} = 0, \tag{5.43}$$

$$w_S\widehat{w}_S - w_U\widehat{w}_U = (w_S - w_U)\theta_{KS}\widehat{r}_S, \tag{5.44}$$

$$\widehat{n} + \widehat{x} = \widehat{S}, \tag{5.45}$$

$$\widehat{S} = \widehat{\overline{K}}_S, \tag{5.46}$$

$$\alpha\lambda_{LM}(\widehat{p}_X - \widehat{w}_U - \frac{\delta}{1-\delta}\widehat{n}) + \lambda_{LR}(\beta\widehat{\tau} - \beta\widehat{w}_U + \widehat{Y}_M + \widehat{Y}_R = -\frac{S}{\overline{L}-S}\widehat{S}, \tag{5.47}$$

$$\widehat{n} = 0, \tag{5.48}$$

$$(1-\beta)(\widehat{w}_U - \widehat{\tau}) + \widehat{Y}_R = 0, \tag{5.49}$$

$$[1+\alpha(\frac{\delta}{1-\delta})]\widehat{n} + \widehat{x} - (1-\alpha)\widehat{w}_U + (1-\alpha)\widehat{p}_X - \widehat{Y}_M = 0. \tag{5.50}$$

where $\lambda_{LM} = [\alpha/(1-\alpha)]^{-\alpha}(w_U/p_X)^{-\alpha}n^{-\alpha\delta/(1-\delta)}w_U$,

and $\lambda_{LR} = [\beta/(1-\beta)]^{-\beta}(w_U/\tau)^{-\beta}(w_U/p_R)$.

Equations (5.40) to (5.50) can be reduced to the following two by two equations system:

$$\begin{pmatrix} -(\lambda_{LM}+\lambda_{LR}/\beta) & \lambda_{LM} \\ \alpha/(1-\alpha) & 1 \end{pmatrix} \begin{pmatrix} \widehat{w}_U \\ \widehat{Y}_M \end{pmatrix} = \begin{pmatrix} -S/(\overline{L}-S) \\ 1 \end{pmatrix} \widehat{\overline{K}}_S. \qquad (5.51)$$

The determinant of the coefficient matrix of (5.51) is denoted as Φ:

$$\Phi = -\frac{1}{\alpha}\lambda_{LM} - \frac{1}{\beta}\lambda_{LR} < 0.$$

The equations system (5.51) is solved by using the Cramer's rule:

$$\frac{\widehat{w}_U}{\widehat{\overline{K}}_S} = -\frac{\lambda_{LM}+S/(\overline{L}-S)}{\Phi} > 0.$$

Combining the above result with equations (5.40) and (5.41) yields:

$$\frac{\widehat{w}_S}{\widehat{\overline{K}}_S} = \frac{(1-\alpha)(\lambda_{LM}+S/(\overline{L}-S))}{\alpha\Phi} > 0.$$

Therefore, $(\widehat{w}_U - \widehat{w}_S)/\widehat{\overline{K}}_S > 0$.

Step 2:

Using the Cramer's rule to solve equations system (5.51) yields:

$$\frac{\widehat{Y}_M}{\widehat{\overline{K}}_S} = -\frac{\lambda_{LM}+\lambda_{LR}/\beta-(1-\alpha)S/\alpha(\overline{L}-S)}{\Phi}.$$

Therefore, $\widehat{Y}_M/\widehat{\overline{K}}_S > (<)0$ if $\lambda_{LM}+\lambda_{LR}/\beta > (<)(1-\alpha)S/\alpha(\overline{L}-S)$.

Combining the results of $\widehat{w}_U/\widehat{\overline{K}}_S$with equations (B-4) and (B-10) yields:

$$\frac{\widehat{Y}_R}{\widehat{\overline{K}}_S} = \frac{\beta[\lambda_{LM}+S/(\overline{L}-S)]}{\Phi(1-\beta)} < 0.$$

Step 3:

Total differentiation of equation (5.12) yields:

$$\frac{\widehat{I}}{\widehat{\overline{K}}_S} = \varphi_M\frac{\widehat{Y}_M}{\widehat{\overline{K}}_S} + \varphi_R\frac{\widehat{Y}_R}{\widehat{\overline{K}}_S}.$$

Combined with the results obtained from the first two steps, we can find that $\widehat{I}/\widehat{\overline{K}}_S > 0$ if:

$$\begin{aligned}
\lambda_{LM} + \frac{\lambda_{LR}}{\beta} &> \frac{(1-\alpha)S}{\alpha(\overline{L}-S)} \\
\text{and } \frac{\varphi_M}{\varphi_R} &> \frac{\beta[\lambda_{LM} + S/(\overline{L}-S)]}{(1-\beta)\lambda_{LM} + (1-\beta)\lambda_{LR}/\beta - (1-\beta)(1-\alpha)S/\alpha(\overline{L}-S)}.
\end{aligned}$$

6 Concluding Remarks

6.1 Main Findings

In this dissertation, we discuss the competition policies and industrial policies in different market structures. We study a particular market structure where large firms and small firms coexist. In this mixed market structure, we investigate the impacts of the entry and merger behavior of firms, which has significant implications for such competition policies as entry restrictions and antitrust laws. Another issue addressed is the impact of some industrial policies in different market structures.

We investigate the competition of the big and small and related competition policies in two respects. First, we examine the impacts of the large firm's entry and highlight the role of different levels of substitution across the big and the small in determining the impacts on incumbent firms' behavior and social welfare. Second, we identify the choice on product range by the merged large firms and how the post-merger product choice influences the behavior of non-participating firms and social welfare.

Chapter 3 investigates the first issue, i.e. the entry issue in the market with large and small firms. In the differentiated good market, there are a few large firms and a continuum of small firms. We differentiate the big from the small in the following three respects: 1) each large firm has a market impact in that it supplies a continuum of varieties with a positive measure, while each small firm has a negligible impact on the market for it supplies one variety with a zero measure; 2) the large firms are incumbents, while the small firms freely enter or exit from the market; and 3) the product substitution level may differ across the varieties of the large firms and those of the small firms. We find that the impact of a large firm's entry hinges on the different levels of substitution across the big and small. A new large entrant generates two effects on the incumbent large firms, the pro-competitive substitution effect and the squeezing effect on the small firms that indirectly causes market expansion for the large firms. If the cross substitution level is relatively larger than the substitution level within large firms and small firms, the pro-competitive substitution effect is dominated by the squeezing effect, which raises the market power of the large firms so that the large incumbents enjoy more market power. The welfare effects are also ambiguous, depending on the comparison of substitution levels and efficiency across the big and the small.

Chapter 4 discusses the second issue, i.e. the merger of large firms with product choice in the presence of small firms. The framework is different from that of Chapter 3 in the following ways: 1) both large and small firms are singleproduct firms, but the market powers of each large firm and small firm are polarized as in Chapter 3; 2) the merged firm faces a choice on the range of varieties. In our model, it is shown that different product choices by the merged firm generate opposite impacts on the competitive fringe and social welfare. If the merged firm chooses to shrink its product range, more small firms are induced to enter the market, but consumer welfare deteriorates. In contrast, the merged firm' choice to maintain its product range squeezes some small firms out of the market but improves consumer welfare.

Concerning the industrial policies, chapter 5 investigates the impact of education investment on skilled-unskilled wage inequality and economic development. Based on a four-sector general equilibrium framework, it considers a vertical market structure where the producer services sector provides intermediate goods and services to the manufacturing sector. In the basic model, which assumes that all sectors are perfectly competitive, we find that increased education capital investment from the government always reduces skilled-unskilled wage inequality but generates an ambiguous impact on economic development. Economic development, which is measured by the increases in national income, depends on the manufacturing sector, which should occupy a sufficiently large share of national income and expand in terms of its output. However, increased education capital from the government does not necessarily raise the manufactured output. Thus, increased governmental investment in the education sector would conditionally promote economic development. The robustness of the basic model is substantiated by the extended model that incorporates the monopolistic competition feature in the producer services sector.

6.2 Limitations and Future Work

Although the market with large and small firms producing differentiated products is prevalent in reality, very few theoretical works have been done to investigate this market structure. Chapter 3 and Chapter 4 in this dissertation are just the initial efforts made on this topic. These two chapters have the following limitations. 1) Chapter 3 and Chapter 4 are based on a specific utility function. We would like to establish a more general framework to deepen our analysis. 2) Both chapters consider a horizontal relations among firms in an industry, but it is interesting to investigate how the results and mechanisms would change in a vertical market structure. 3) Chapter 3 ignores the asymmetric technology across the varieties within a multi-product large firm; neither does it consider the optimal number of large firms. Thus, introducing asymmetry and endogenizing the number of large firms are two possible extensions. 4) Chapter 4 investigates the merger issue in a market where firms compete in quantity, but it is worth testing the robustness of the results by considering price competition.

As for the education policy studied in this dissertation, considering different cost structures of the producer services sector, and using data or choosing some suitable values of the parameters to calibrate the theoretical model in the present work are two possible ways for future research.

All in all, this dissertation is just an attempt for further studies.

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Figures

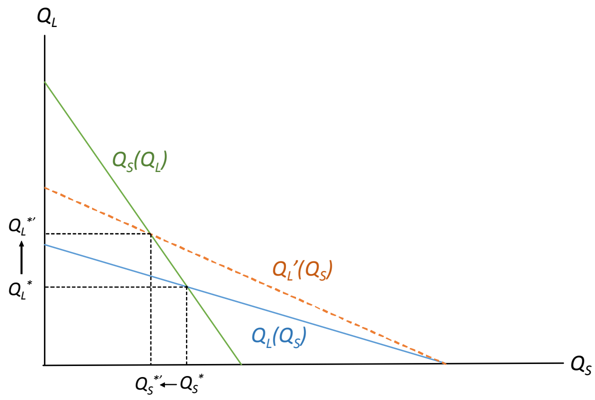

Figure 3.1

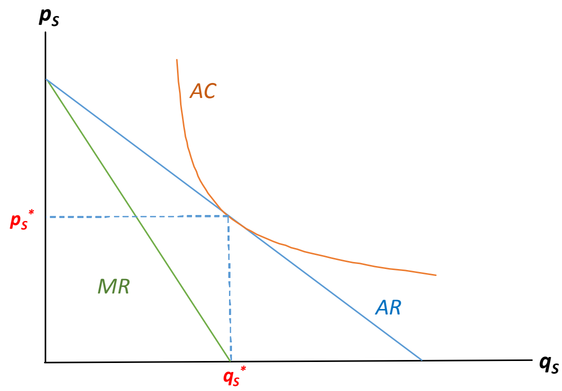

Figure 3.2