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Abstract

In the past few decades, many Taiwanese firms have served as subcontractors to US and Japanese branding firms. This leads to two questions: 1) Why do most subcontractors not establish their own brands in the final goods market? 2) Would they be more likely to become branding firms under certain conditions? This seems to be a common dilemma for many firms in other newly industrialized or developing countries.

This paper builds a simple duopoly model that considers both the vertical and horizontal differentiation in brands. Two players, the US branding firm and the Taiwanese subcontractor, play a two-stage game that decides whether they should cooperate. Under this cooperation scenario, the US branding firm decides to outsource production to the Taiwanese subcontractor and the latter also agrees to take this job.

The result shows that without horizontal differentiation, the subcontractor will become a branding firm only if it is subsidized to do so. However, if 1) the brands are horizontally differentiated; 2) the sunk cost to brand is low; and 3) the brand value for the potential branding firm is high enough, the subcontractor might choose to brand and enter the final goods market even without subsidies. This paper also provides empirical evidence that confirms this argument.

Keywords: Trade; Subcontracting; Brand; Upgrading Strategies

J.E.L. Classification numbers: F14; L22; L24

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1 Introduction

In the past few decades, many firms in developed countries have outsourced their production activities to newly industrialized countries (NICs). From the NICs' point of view, one of the main concerns has become how to take advantage of a higher profit margin by marketing the own brand products. In this case, one might ask about the viability of upgrading the subcontractors in NICs to become own brand manufacturers (OBM firms).

A prominent example is Taiwan, one of the "Four Asian Tigers" in East Asia. Due to its small domestic market, export-oriented firms have played an important role in its economic growth. One conspicuous type of export-oriented Taiwanese firm is the subcontractor, or more specifically, the original equipment manufacturer (OEM firm). OEM firms specialize in production. The only thing OEM firms do not do for their products is branding and marketing in the final goods market, which is done by the outsourcing firm.

Since the 1970s, Many U.S. and Japanese branding firms have outsourced their production activities to Taiwan because of its cheap production costs and the availability of medium-quality labor.[1] Most OEM firms specialize in manufacturing rather than branding and marketing the products they produce worldwide because it is very difficult to compete with incumbent branding firms from developed countries.

Since low-cost labor has been gradually exhausted, the Taiwanese government has encouraged the establishment of high-tech industries and R&D activities.[2] Thus, in addition to manufacturing, more and more Taiwanese subcontractors are also participating in R&D activities and finally becoming original design manufacturers (ODM firms). However, most of them are still subcontractors to foreign outsourcing firms. Only a few of them have chosen to be branding firms in the final goods markets so far.

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[1] See p.214 in Wang and Mai (2001).
[2] The establishment of Hsin-Chu Science-based Industrial Park in 1979 is a prominent example.

Taking the information technology industries as an example, in 2006, the five major Taiwanese laptop subcontractors, Quanta Computer, Compal Electronics, Wistron, Inventec, and Asustek Computer, accounted for 85.5% of world output.[3] They produced the laptops for Dell, Hewlett Packard, Toshiba, Apple, Sony, Acer, Lenovo, and many other branding firms. Hon Hai Precision Industry (also named Foxconn Technology Group) produces iPods and iPhones for Apple.[4] Hon Hai Precision Industry also produces cell phones, networking equipment, and game consoles for its customers, including Dell, Hewlett Packard, Nokia, Cisco, Sony, Nintendo, and Motorola. (BusinessWeek, 2006; 2007).

Table 1-1 and Table 1-2 confirm this striking pattern. That is, although Taiwan's IT industries have distinctly high world market shares and some of them even dominate the world markets, many firms still choose not to be OBM firms. Why is this the case? Very few studies until now have discussed the possibility for a subcontractor to establish its own brand. Most research has considered the relevant issues from the developed country's point of view. For instance, to access the foreign market, whether a firm should export, engage in horizontal foreign direct investment (FDI) or vertical FDI (Markusen et al., 1996; Markusen, 1997; Markusen, 2002), and whether a firm should choose FDI or should contract with a local agent (Horstmann and Markusen, 1996; Du, Lu, and Tao, 2005).[5] Besides, most studies investigating issues regarding brand have focused on its role of signaling (Wernerfelt, 1988; Price and Dawar, 2002; Hakenes and Peitz, 2004); none of them have discussed the subcontractors' concerns about branding.

Feenstra, et al. (1999), on the other hand, compare the business groups among South Korea, Taiwan, and Japan and find that unlike South Korea and Japan, the business groups in Taiwan are smaller and less vertically-integrated. They argue that the chaebol (large business group) in South

[3] See http://tt.acesuppliers.com/news/new_1.asp?newsid=13176. The data are from RIC, a research institute in China. According to BusinessWeek's Info Tech 100 survey, Compal Electronics, Wistron, Inventec, and Asustek Computer are among the top 100 IT firms (BusinessWeek July 2, 2007).

[4] According to BusinessWeek's Info Tech 100 survey, Hon Hai Precision Industry ranks No.4 which even surpasses Apple, which ranks No. 6 (BusinessWeek July 2, 2007).

[5] Other issues relevant to outsourcing and subcontracting include: 1) the factors that determine the market structure, and 2) firm's decisions about where to outsource (see Grossman and Helpman, 2002; 2005).

Korea can be viewed as a single multi-product firm because developing a better reputation on one product would lead to an increase in the demand for all its products. Therefore, the chaebol has more incentive to produce high-quality goods. Their empirical evidence also confirms this hypothesis.

Although their research focuses on the quality of the product rather than the brand, it seems to suggest that the "stand-alone" subcontractors in developing countries or other NICs might have fewer incentives to establish their own brands in the final goods markets. However, the interaction between the foreign outsourcing firm (which is a branding firm) and the domestic subcontractor is beyond the scope of their research.

Another study that examines the feasibility for the subcontractors to upgrade by branding is Chu (2006). She discusses how the second-movers can continue to upgrade once the growth of subcontracting opportunities has been gradually exhausted. She finds that without strong and long-term support from the government, such as South Korea’s government support of the chaebol, most Taiwanese subcontractors will still choose to be the OEM or ODM firms.

Chu's analyses are based on Amsden and Chu's second-mover theory (Amsden and Chu, 2003) and Penrose's resource-based approach (Penrose, 1959/1995). Chu emphasizes the role of history and accumulated organizational ability in deciding the subcontractor's strategies. This paper, on the other hand, will take a different method. It analyzes the subcontractor's strategies using a two-stage game to answer the following question: Under what circumstances would a Taiwanese subcontractor choose to establish its own brand in the final goods market? This approach could complement Chu’s model.

To answer the above question, this paper builds a model with both vertical and horizontal differentiation of brand values. Two players, the US branding firm U and the Taiwanese OEM firm T, play a two-stage game in the US market. In the first stage, they play a non-cooperative game in a given environment. The purpose of this stage is to figure out the non-cooperative Nash equilibrium outcome. No production activity will be carried out. In the second stage, they play a two-person cooperative game that takes the Nash equilibrium from the first stage game as a given (The Nash equilibrium is just the combination of each firm's outside option). The two firms now bargain over the total industrial profit when they cooperate. In this paper, cooperation means U outsources T to produce and T is the subcontractor of U. The two-stage game presented here is similar in spirit to the biform model presented by Brandenburger and Stuart (2007).

If the bargain succeeds, the two firms cooperate, i.e., the US branding firm decides to outsource production to the Taiwanese OEM firm and the latter also agrees to be the subcontractor. They share the total industrial profit. However, if the bargain fails, then each firm must exercise its outside option, i.e., each firm will either be the branding firm that produces on its own or exit the market.

The result shows that without horizontal differentiation, the Taiwanese OEM firm will become a branding firm only if it is subsidized to do so. However, if the Taiwanese OEM firm can horizontally differentiate its brand, the sunk cost to brand is not too large, and the brand value for the new Taiwanese branding firm is high enough, it might choose to brand and enter the final goods market even without any subsidy.

The intuition behind this result is that without horizontal differentiation, monopoly profit is always the highest. Furthermore, the higher brand value from the incumbent outsourcing firm and the lower production cost from the subcontractor should be the best combination to achieve the highest total industrial profit. Thus, the bargain will succeed in this case.

Nevertheless, with horizontal differentiation, when the subcontractor decides to brand, it could be the case that the two OBM firms are indeed two monopolists targeting two totally different groups of consumers. If this is not feasible, the new OBM firm could set up a price that is high enough not to trigger any competition between firms, or it could engage in a duopoly competition with the incumbent OBM firm. In all these cases, the bargain might fail since the sum of the non-cooperative profits could be higher than the total industrial profit under cooperation.

The paper is organized as follows: Section 2 presents the model settings, Section 3 derives some implications of the model and gives numerical examples, Section 4 gives the empirical evidence, and Section 5 provides a conclusion.

Table 1-1 Percentage of OEM & ODM Exports by Taiwan's IT Industries

Unit: %	1993	1995	1997	1998	1999	2000	2001	2002
Laptop Computer	77	79	82	85	87	90	92	93
Monitor*	69		68	67	68	75	79	
Desktop Computer	49	37	65	72	76	82	84	
Motherboard			20	31	29	36	34	38
CD-ROM		79	37	31	37	48	62	63
Scanner			36	43	50	59	69	
Digital Camera					90	87		
Total			62	64	65.1	74.6		75.9

*For LCD monitor from 2000, and CRT monitor before 2000.
Source: Chu (2006).[6]

Table 1-2 World Market Shares for Taiwan's IT Industries

Unit: %	1993	1995	1997	1998	1999	2000	2001	2002	2005	2006
Laptop	22	29	31	40	49	53	55	61	73	90
Monitor(CRT)	51	57	55	58	58	54	51	51		
Monitor(LCD)							56	61		
Desktop	8	10	11	20	19	25	24	23		
Motherboard	83	65	68	72	64	70	70	75		
SPS	30	35	62	65	70	74				
CD-ROM		11	22	34	34	39				
Scanner	55	64	71	85	91	93				
Digital Camera							36	39		
Key Board	49	65	61	68	68					
Mouse	80	72	62	59	58					

Source: Chu (2006) ; Market shares for laptop computer in 2005 and 2006 come from RIC's report.[7]

[6] Chu (2006) collects the data from the Market Information Center (MIC) of Institute for Information Industry, Taiwan.
[7] See http://tt.acesuppliers.com/news/new_1.asp?newsid=13176 Research In China (RIC) is a research institute in China.

2 Model

This paper builds a model such that the brands are both vertically and horizontally differentiated.[8] There are two players, the US branding firm U and the Taiwanese OEM firm T. U can choose to be a branding firm that outsources, an OBM firm (branding firm that produces on its own), or exit, while T can choose to be an OEM firm (subcontractor), an OBM firm, or exit, as shown in Table 2-1.

The paper assumes that U and T play a two-stage game in the US market. In the first stage, they play a non-cooperative game, as shown in the gray area in Table 2-1. Since U is the incumbent in the market, this paper assumes that U is the leader while T is the follower. The purpose of playing the non-cooperative game is solely to find the Nash equilibrium which will be used later. Thus, no production activity will be carried out in the first stage.

In the second stage, they play a two-person cooperative game that takes the Nash equilibrium from the non-cooperative game as given. If the bargain in the second stage game succeeds, the two firms cooperate, i.e., the US branding firm outsources the Taiwanese OEM firm and the latter also agrees to be the subcontractor. They share the total industrial profit π_O^I together. If the bargain fails, each firm's outside option must be carried out, i.e., each firm will either be a branding firm that produces on its own or exit.

2.1 Model Setting

Let us assume that the US market is populated by consumers with a population of size N^U. Each consumer's preference is characterized by the uniformly distributed parameter v, where $v \in [\alpha, \alpha + 1]$ and $\alpha \geq 0$. Also, U locates at $\alpha + 1$ and T locates at α if it enters. Each consumer will purchase exactly one product or not purchase at all. For any consumer, if he purchases from U, his

[8] In the first proposition which will be presented later, the paper shows that if the brands are only vertically differentiated, when both T's brand value and production cost are lower than those for U, the bargain in the second stage game would fail only if T is "over-subsidized" to establish its brand, i.e., without subsidy, T will always choose to be the subcontractor of U.

utility will be:

$$u = vb - p$$

Unlike the typical vertical product differentiation model, the parameter b does not represent the quality of the product.[9] In this paper, b represents the perceived brand value on a particular product, i.e., higher b means better brand reputation. Since if T enters, it is assumed to locate at α, if the consumer purchases from T, his utility becomes:

$$u = (2\alpha + 1 - v)b - p$$

If the two firms coexist in the final goods market, the consumer's problem becomes:

$$max\ (vb^U - p^U, (2\alpha + 1 - v)b^T - p^T)$$

Here are several key assumptions. First, the levels of b for both firms are given and not choice variables. The only choice variable for each firm is its own price. Second, since T will be the novice in the final goods market when it becomes an OBM firm, this paper only considers the case in which U has higher brand reputation than T has, i.e., $b^U > b^T > 0$. Third, the model assumes that $0 < c^U < b^U$, $0 < c^T < b^T$, and $c^T < c^U$. Here c^U and c^T denote U's and T's marginal production cost, respectively.

2.2 The First Stage Non-cooperative Game

The solution to the first stage non-cooperative game is determined by $\{b^U, b^T, c^U, c^T, N^U, K_B^T, \alpha\}$. Let us first characterize each firm's profit maximization problems as shown below.

Case 1: U is the only OBM firm in the final goods market

When U is the only OBM firm in the final goods market, the demand for U's product can be expressed as:

[9] See details in p.96-97 in Tirole (1988).

$$Q_{B1}^U = \begin{cases} 0, \ \frac{p_{B1}^U}{b^U} \geq \alpha + 1 \\ \left(\alpha + 1 - \frac{p_{B1}^U}{b^U}\right) N^U, \ \frac{p_{B1}^U}{b^U} \in (\alpha, \alpha + 1) \\ (\alpha + 1 - \alpha) N^U, \ \frac{p_{B1}^U}{b^U} \leq \alpha \end{cases} \quad (1)$$

Note that when $\frac{p_{B1}^U}{b^U} \in (\alpha, \alpha + 1)$, the market is not fully occupied. When $\frac{p_{B1}^U}{b^U} \leq \alpha$, the market is fully occupied. The profit function becomes:

$$\pi_{B1}^U = \begin{cases} 0, \ \frac{p_{B1}^U}{b^U} \geq \alpha + 1 \\ max_{p_{B1}^U} (p_{B1}^U - c^U) \left(\alpha + 1 - \frac{p_{B1}^U}{b^U}\right) N^U, \ \frac{p_{B1}^U}{b^U} \in (\alpha, \alpha + 1) \\ max_{p_{B1}^U} (p_{B1}^U - c^U) N^U, \ \frac{p_{B1}^U}{b^U} \leq \alpha \end{cases}$$

The pricing equation and the profit function can be derived accordingly:[10]

$$p_{B1}^U = \begin{cases} (\alpha + 1) b^U, \ \frac{p_{B1}^U}{b^U} \geq \alpha + 1 \\ \frac{1}{2}[(\alpha + 1) b^U + c^U], \ \frac{p_{B1}^U}{b^U} \in (\alpha, \alpha + 1) \\ \alpha b^U, \ \frac{p_{B1}^U}{b^U} \leq \alpha \end{cases} \quad (2)$$

$$\pi_{B1}^U = \begin{cases} 0, \ \frac{p_{B1}^U}{b^U} \geq \alpha + 1 \\ \frac{1}{4b^U}[(\alpha + 1) b^U - c^U]^2 N^U, \ \frac{p_{B1}^U}{b^U} \in (\alpha, \alpha + 1) \\ (\alpha b^U - c^U) N^U, \ \frac{p_{B1}^U}{b^U} \leq \alpha \end{cases} \quad (3)$$

Case 2: T is the only OBM firm in the final goods market

When T is the only OBM firm in the final goods market, its demand can be expressed as:

$$Q_{B1}^T = \begin{cases} 0, \ \frac{p_{B1}^T}{b^T} \geq \alpha + 1 \\ \left(2\alpha + 1 - \frac{p_{B1}^T}{b^T} - \alpha\right) N^U, \ 2\alpha + 1 - \frac{p_{B1}^T}{b^T} \in (\alpha, \alpha + 1) \\ (\alpha + 1 - \alpha) N^U, \ 2\alpha + 1 - \frac{p_{B1}^T}{b^T} \geq \alpha + 1 \end{cases} \quad (4)$$

[10] In fact, any $p_{B1}^U \geq (\alpha + 1) b^U$ always gives the same result since the corresponding demand Q_{B1}^U will be zero. The situation for p_{B1}^T when $\frac{p_{B1}^T}{b^T} \geq \alpha + 1$ is similar (see Case 2).

Note that when $2\alpha + 1 - \frac{p_{B1}^T}{b^U} \in (\alpha, \alpha + 1)$, the market is not fully occupied. When $2\alpha + 1 - \frac{p_{B1}^T}{b^U} \geq \alpha + 1$, the market is fully occupied. The profit function becomes:

$$\pi_{B1}^T = \begin{cases} -K_B^T,\ \frac{p_{B1}^T}{b^U} \geq \alpha + 1 \\ max_{p_{B1}^T}(p_{B1}^T - c^T)\left(2\alpha + 1 - \frac{p_{B1}^T}{b^T} - \alpha\right)N^U - K_B^T,\ 2\alpha + 1 - \frac{p_{B1}^T}{b^T} \in (\alpha, \alpha + 1) \\ max_{p_{B1}^T}(p_{B1}^T - c^T)N^U - K_B^T,\ 2\alpha + 1 - \frac{p_{B1}^T}{b^T} \geq \alpha + 1 \end{cases}$$

The pricing equation and the profit function can be derived accordingly:

$$p_{B1}^T = \begin{cases} (\alpha + 1)b^T,\ \frac{p_{B1}^T}{b^T} \geq \alpha + 1 \\ \frac{1}{2}[(\alpha + 1)b^T + c^T],\ 2\alpha + 1 - \frac{p_{B1}^T}{b^T} \in (\alpha, \alpha + 1) \\ \alpha b^T,\ 2\alpha + 1 - \frac{p_{B1}^T}{b^T} \geq \alpha + 1 \end{cases} \tag{5}$$

$$\pi_{B1}^T = \begin{cases} -K_B^T,\ \frac{p_{B1}^T}{b^U} \geq \alpha + 1 \\ \frac{1}{4b^T}[(\alpha + 1)b^T - c^T]^2 N^U - K_B^T,\ 2\alpha + 1 - \frac{p_{B1}^T}{b^T} \in (\alpha, \alpha + 1) \\ (\alpha b^T - c^T)N^U - K_B^T,\ 2\alpha + 1 - \frac{p_{B1}^T}{b^T} \geq \alpha + 1 \end{cases} \tag{6}$$

Case 3: The two firms are monopolists in different markets

When both firms do enter the final goods market but each firm's pricing strategy has no effect on the other firm, they are not competing with each other at all. Each firm's market is totally different from the other firm's market as shown in Figure 2-2 (Case 3). The demand function, profit function, and pricing equation for each firm are the same as in the non-fully-occupied monopoly cases. The only difference is that the two firms coexist. In this case, when plugging the monopoly prices back into the utility function, the intersection of $u = (2\alpha + 1 - v)b^T - p^T$ and $u = vb^U - p^U$ must satisfy the following two conditions:

$$\frac{[p_{B1}^U - p_{B1}^T + (2\alpha+1)b^T]}{b^U + b^T} \in (\alpha, \alpha + 1) \tag{7}$$

$$\frac{[p_{B1}^U - p_{B1}^T + (2\alpha+1)b^T]}{b^U + b^T} b^U - p_{B1}^U \leq 0 \tag{8}$$

(7) means that the horizontal coordinate of the intersection must lie between α and $\alpha+1$, (8) says the vertical coordinate of the intersection must be less than or equal to zero.

Case 4: The two firms enter in different markets but only U is the monopolist

When (8) in Case 3 is not true, the market cannot accommodate two firms both acting as if they were monopolists in different markets. Let us consider the case that U, the incumbent, does not occupy the whole market as a monopoly (if U has already occupied the whole market in the first place, a duopolistic competition will be triggered after T enters). Now, if T decides to enter and not to compete with U, then U still can earn the monopoly profit. T only captures the residual demand and solves its constrained maximization problem by setting a price p_{B1}^{TN} higher than T's monopoly price, i.e., $p_{B1}^{TN} > p_{B1}^{T}$ such that the market is just fully occupied, as shown in Figure 2-2 (Case 4).[11] Each firm's profit maximization problem becomes:

$$\pi_{B1}^{U} = max_{p_{B1}^{U}}(p_{B1}^{U} - c^{U})\left(\alpha + 1 - \frac{p_{B1}^{U}}{b^{U}}\right)N^{U},\ \frac{p_{B1}^{U}}{b^{U}} \in (\alpha, \alpha+1)$$

$$\pi_{B1}^{T} = max_{p_{B1}^{TN}}(p_{B1}^{TN} - c^{T})\left(2\alpha + 1 - \frac{p_{B1}^{TN}}{b^{T}} - \alpha\right)N^{U} - K_{B}^{T},\ 2\alpha + 1 - \frac{p_{B1}^{TN}}{b^{T}} - \alpha \leq \alpha + 1 - \frac{p_{B1}^{U}}{b^{U}}$$

The constraint in T's maximization problem says that T should set its price p_{B1}^{TN} in a way such that it will not steal any customers from U. Since T's monopoly price p_{B1}^{T} is lower than p_{B1}^{TN} and the profit function is concave, the constraint will be binding. The pricing equation and the profit function can be derived accordingly:

$$p_{B1}^{U} = \frac{1}{2}[(\alpha+1)b^{U} + c^{U}],\ \frac{p_{B1}^{U}}{b^{U}} \in (\alpha, \alpha+1) \tag{9}$$

$$\pi_{B1}^{U} = \frac{1}{4b^{U}}[(\alpha+1)b^{U} - c^{U}]^{2}N^{U},\ \frac{p_{B1}^{U}}{b^{U}} \in (\alpha, \alpha+1) \tag{10}$$

$$p_{B1}^{TN} = \frac{b^{T}}{2b^{U}}[(\alpha+1)b^{U} + c^{U}] = \frac{b^{T}}{b^{U}}p_{B1}^{U} \tag{11}$$

$$\pi_{B1}^{TN} = \frac{\{b^{U}[(\alpha+1)b^{T} - 2c^{T}] + b^{T}c^{U}\}[(\alpha+1)b^{U} - c^{U}]}{4(b^{U})^{2}}N^{U} - K_{B}^{T} \tag{12}$$

[11] Note that $u = (2\alpha + 1 - v)b^{T} - p^{T}$ shifts downward when T sets a higher price.

When the market cannot accommodate two monopolists and T decides to enter the market and compete with U, there are three possibilities as presented in Cases 5 to 8.

Case 5: The two firms are duopolists and no constraints are binding

Now, the two firms play a Stackelberg game with U and T being the leader and the follower, respectively. The demand for each firm's product will be determined by the intersection of $u = (2\alpha + 1 - v)b^T - p^T$ and $u = vb^U - p^U$ at the Stackelberg prices as shown in Figure 2-2 (Case 5). Let us denote the coordinate of the above intersection by (x, y). The necessary conditions for Case 5 to hold are that the following constraints will not be binding.

$$x = \frac{[p_{B2}^U - p_{B2}^T + (2\alpha+1)b^T]}{b^U + b^T} \geq \alpha \tag{13}$$

$$x = \frac{[p_{B2}^U - p_{B2}^T + (2\alpha+1)b^T]}{b^U + b^T} \leq \alpha + 1 \tag{14}$$

$$y = \frac{[p_{B2}^U - p_{B2}^T + (2\alpha+1)b^T]}{b^U + b^T} b^U - p_{B2}^U \geq 0 \tag{15}$$

If none of the inequalities (13), (14), and (15) is binding, the demand becomes:

$$Q_{B2}^U = \left(\alpha + 1 - \frac{p_{B2}^U - p_{B2}^T + (2\alpha+1)b^T}{b^U + b^T}\right) N^U \tag{16}$$

$$Q_{B2}^T = \left(\frac{p_{B2}^U - p_{B2}^T + (2\alpha+1)b^T}{b^U + b^T} - \alpha\right) N^U \tag{17}$$

Here are U and T's profit maximization problems, respectively:

$$\pi_{B2}^U = max_{p_{B2}^U} (p_{B2}^U - c^U) \left(\alpha + 1 - \frac{p_{B2}^U - p_{B2}^T + (2\alpha+1)b^T}{b^U + b^T}\right) N^U$$

$$\pi_{B2}^T = max_{p_{B2}^T} (p_{B2}^T - c^T) \left(\frac{p_{B2}^U - p_{B2}^T + (2\alpha+1)b^T}{b^U + b^T} - \alpha\right) N^U - K_B^T$$

Since U is the leader, it will take into account T's reaction function when setting its price p_{B2}^U. T's reaction function is just the first order condition of its profit maximization problem:

$$p_{B2}^T = \frac{(\alpha+1)b^T + c^T - \alpha b^U + p_{B2}^U}{2} \tag{18}$$

U's pricing strategy can be found by plugging (18) into its maximization problem:[12]

$$p_{B2}^U = \frac{(\alpha+2)b^U + (-\alpha+1)b^T + c^T + c^U}{2} \tag{19}$$

T's pricing strategy is determined by plugging (19) back into (18):

$$p_{B2}^T = \frac{(\alpha+3)b^T + (-\alpha+2)b^U + 3c^T + c^U}{4} \tag{20}$$

U's and T's profit functions can be derived accordingly as:

$$\pi_{B2}^U = \frac{\left[(\alpha+2)b^U + (-\alpha+1)b^T + c^T - c^U\right]^2}{8(b^U + b^T)} N^U \tag{21}$$

$$\pi_{B2}^T = \frac{\left[(-\alpha+2)b^U + (\alpha+3)b^T - c^T + c^U\right]^2}{16(b^U + b^T)} N^U - K_B^T \tag{22}$$

When plugging the nonbinding solution p_{B2}^U and p_{B2}^T into the inequalities (13), (14), and (15), if one of them is violated, then the corresponding constraint is binding. Case 6 presents the situation when the horizontal coordinate of the intersection x under the nonbinding solutions p_{B2}^U and p_{B2}^T is less then α (so, $x \geq \alpha$ is binding). Case 7 deals with the situation when $x \leq \alpha + 1$ is binding, and Case 8 is for the situation when $y \geq 0$ is binding.[13] Note that at equilibrium, at most one of the inequalities (13), (14), and (15) is binding. This is demonstrated in appendix A-03.

Case 6: The two firms are duopolists and the constraint $x \geq \alpha$ is binding

If the nonbinding solution p_{B2}^U and p_{B2}^T makes $\frac{[p_{B2}^U - p_{B2}^T + (2\alpha+1)b^T]}{b^U + b^T} < \alpha$, then $x \geq \alpha$ is binding. This means that to maximize its profit, U will not set its price that low. Besides, from T's reaction function, $\frac{\partial p_{B2}^T}{\partial p_{B2}^U} = \frac{1}{2}$. Thus, to find the solution, both p_{B2}^U and p_{B2}^T have to be raised until $x = \alpha$, as shown in Figure 2-2 (Case 6). Let us denote U's duopoly profit by π_{B2}^{UL}. Since T's demand is zero, its profit becomes $-K_B^T$ under the duopoly.[14]

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[12] The complete derivation is presented in appendix A-01.
[13] The complete derivation is presented in appendix A-02.
[14] When $x \geq \alpha$ is binding, the final outcome becomes Case 1, i.e., T leaves so U can earn the monopoly profit.

Case 7: The two firms are duopolists and the constraint $x \leq \alpha + 1$ is binding

If the nonbinding solution p_{B2}^{U} and p_{B2}^{T} makes $x > \alpha + 1$ in (13), then $x \leq \alpha + 1$ is binding. This means to maximize its profit, U will not set its price that high. Besides, from T's reaction function, $\frac{\partial p_{B2}^{T}}{\partial p_{B2}^{U}} = \frac{1}{2}$. So, both p_{B2}^{U} and p_{B2}^{T} have to be dropped until $x = \alpha + 1$, as shown in Figure 2-2 (Case 7). Thus, the equilibrium prices are determined by solving T's reaction function (17) and the binding constraint $x = \alpha + 1$ simultaneously. They are:

$$p_{B2}^{UH} = (\alpha + 2)b^{U} + (1 - \alpha)b^{T} + c^{T} \tag{23}$$

$$p_{B2}^{TH} = b^{U} + b^{T} + c^{T} \tag{24}$$

Note that U's demand Q_{B2}^{TH} and profit π_{B2}^{TH} will be zero because under the binding constraint $x = \alpha + 1$, T's product dominates U's product for every consumer. T's demand and profit are:[15]

$$Q_{B2}^{TH} = (\alpha + 1 - \alpha)N^{U} \tag{25}$$

$$\pi_{B2}^{TH} = (b^{U} + b^{T})N^{U} - K_{B}^{T} \tag{26}$$

Case 8: The two firms are duopolists and the constraint $y \geq 0$ is binding

If the nonbinding solution makes $y = \frac{[p_{B2}^{U} - p_{B2}^{T} + (2\alpha+1)b^{T}]}{b^{U}+b^{T}} b^{U} - p_{B2}^{U} < 0$, then the constraint $y \geq 0$ is binding. This means that to maximize its profit, U will not set its price that high. Besides, from T's reaction function, $\frac{\partial p_{B2}^{T}}{\partial p_{B2}^{U}} = \frac{1}{2}$. So, both p_{B2}^{U} and p_{B2}^{T} have to be lowered until the condition $y = 0$ is met, as shown in Figure 2-2 (Case 8). Now, U's profit maximization problem becomes:

$$\pi_{B2}^{UY} = max_{p_{B2}^{UY}} (p_{B2}^{UY} - c^{U}) \left(\alpha + 1 - \frac{p_{B2}^{UY} - p_{B2}^{TY} + (2\alpha+1)b^{T}}{b^{U}+b^{T}} \right) N^{U}$$

$$s.t.\ \ p_{B2}^{TY} = \frac{(\alpha+1)b^{T} + c^{T} - \alpha b^{U} + p_{B2}^{UY}}{2} \ \ and\ \ y = \frac{p_{B2}^{UY} - p_{B2}^{TY} + (2\alpha+1)b^{T}}{b^{U}+b^{T}} b^{U} - p_{B2}^{UY} \geq 0$$

[15] When $\pi_{B2}^{TH} > 0$, the outcome ends up to be Case 2, i.e., T is the monopolist since U leaves. When $\pi_{B2}^{TH} \leq 0$, U will be the monopolist since T will not enter, i.e., the outcome is Case 1.

The first constraint is T's reaction function while the second constraint $y \geq 0$ will be binding as discussed above. The solution is found by solving the following two equations simultaneously.

$$p_{B2}^{TY} = \frac{(\alpha+1)b^T + c^T - \alpha b^U + p_{B2}^{UY}}{2} \tag{27}$$

$$\frac{p_{B2}^{UY} - p_{B2}^{TY} + (2\alpha+1)b^T}{b^U + b^T} b^U - p_{B2}^{UY} = 0 \tag{28}$$

The pricing equation and profit function for U are:

$$p_{B2}^{UY} = \frac{b^U[\alpha b^U + (3\alpha+1)b^T - c^T]}{b^U + 2b^T} \tag{29}$$

$$\pi_{B2}^{UY} = \frac{\left[\alpha(b^U)^2 + (3\alpha+1)b^U b^T - (c^T + c^U)b^U - 2c^U b^T\right]\left[(b^U)^2 + (-\alpha+1)(b^T)^2 + (-\alpha+2)b^U b^T + c^T(b^U + b^T)\right]}{(b^U + b^T)(b^U + 2b^T)^2} \tag{30}$$

Also, the pricing equation and the profit function for T are:

$$p_{B2}^{TY} = \frac{b^T[(\alpha+1)b^U + (\alpha+1)b^T + c^T]}{b^U + 2b^T} \tag{31}$$

$$\pi_{B2}^{TY} = \frac{\left[(\alpha+1)(b^T)^2 + (\alpha+1)b^U b^T - c^T b^U - c^T b^T\right]^2}{(b^U + b^T)(b^U + 2b^T)^2} - K_B^T \tag{32}$$

Let us prove that given the parameters $\{b^U, b^T, c^U, c^T, N^U, K_B^T, \alpha\}$, there exists a unique pure strategy Nash equilibrium in the first stage non-cooperative game.

Lemma 2.2.1

Suppose each firm will stay in the market only if it can earn a positive profit, and when T enters, it will not fight with U (the incumbent) if T's duopoly profit is no larger than its maximum profit without triggering a duopolistic competition. Then, there exists a unique pure strategy Nash equilibrium to the first stage non-cooperative game.

Proof:

If both firms choose to enter, the six possible outcomes would be Case 3 through Case 8 as discussed above. There will be six corresponding possible non-cooperative games, Case a through Case f, as shown in the extensive form representations in Figure 2-3. However, given the parameters $\{b^U, b^T, c^U, c^T, N^U, K_B^T, \alpha\}$, only one of them holds at a time. If the market can accommodate two monopolists, the first stage game will be Case a. If the market cannot accommodate two monopolists but T still enters to maximize its profit, it chooses whether or not to compete with U. If T chooses not to compete with U, the first stage game becomes Case b. If T decides to compete with U, exactly one of Case c through f holds since T's decision triggers a duopolistic competition. If after both firms enter, Case 5 (Nonbinding duopolistic competition) is the outcome, the first stage game becomes Case c. Appendix A-03 shows that at most only one constraint will be binding. If $x \geq \alpha$ is binding, the first stage game becomes Case d. If $x \leq \alpha + 1$ is binding, it becomes Case e. Finally, if $y \geq 0$ is binding, it becomes Case f.

Let us first consider Case a. Note that $\pi_{B1}^U > 0$ always holds since $b^U > c^U$ by assumption. Now, if $\pi_{B1}^T > 0$, the Nash equilibrium is $(Enter, Enter)$ since both firms' dominant strategies are to enter. If $\pi_{B1}^T \leq 0$, U's dominant strategy is to enter while that for T is not to enter. The outcome becomes $(Enter, Not\ enter)$. Similarly, we can prove that in Case b, if $\pi_{B1}^{TN} > 0$, the outcome is $(Enter, Enter)$ while if $\pi_{B1}^{TN} \leq 0$, it becomes $(Enter, Not\ enter)$. In Case c, if $\pi_{B2}^T > 0$, the outcome is $(Enter, Enter)$ while if $\pi_{B2}^T \leq 0$, it becomes $(Enter, Not\ enter)$. In Case d, the outcome will be $(Enter, Not\ enter)$ since T is the follower and its profit will be non-positive if it enters. In Case e, when $\pi_{B2}^{TH} > 0$, the outcome ends up to be $(Not\ enter, Enter)$. When $\pi_{B2}^{TH} \leq 0$, it becomes $(Enter, Not\ enter)$. In Case f, if $\pi_{B2}^{UY} > 0$ and $\pi_{B2}^{TY} > 0$, the outcome is $(Enter, Enter)$. If $\pi_{B2}^{UY} > 0$ and $\pi_{B2}^{TY} \leq 0$, it becomes $(Enter, Not\ enter)$. If $\pi_{B2}^{UY} \leq 0$ and $\pi_{B2}^{TY} > 0$, the outcome is $(Not\ enter, Enter)$. If $\pi_{B2}^{UY} \leq 0$ and $\pi_{B2}^{TY} \leq 0$, since U, the leader, will enter the market and earn the monopoly profit in the first place, the outcome is $(Enter, Not\ enter)$.

Q.E.D.

2.3 The Second Stage Cooperative Game

In the second stage, both firms play the Nash bargaining game on the total industrial profit π_O^I. If the bargain succeeds, then U and T cooperate such that T produces for U, and the demand for the OEM product with U's brand can be expressed as:

$$Q_O^U = \begin{cases} 0, \ \frac{p_O^U}{b^U} \geq \alpha + 1 \\ \left(\alpha + 1 - \frac{p_O^U}{b^U}\right) N^U, \ \frac{p_O^U}{b^U} \in (\alpha, \alpha + 1) \\ (\alpha + 1 - \alpha) N^U, \ \frac{p_O^U}{b^U} \leq \alpha \end{cases} \tag{33}$$

Note that when $\frac{p_O^U}{b^U} \in (\alpha, \alpha + 1)$, the market is not fully occupied. When $\frac{p_O^U}{b^U} \leq \alpha$, the market is fully occupied. When $\frac{p_O^U}{b^U} \geq \alpha + 1$, the demand is zero. The profit maximization problem becomes:

$$\pi_O^I = \begin{cases} 0, \ \frac{p_O^U}{b^U} \geq \alpha + 1 \\ max_{p_O^U} (p_O^U - c^T) \left(\alpha + 1 - \frac{p_O^U}{b^U}\right) N^U, \ \frac{p_O^U}{b^U} \in (\alpha, \alpha + 1) \\ max_{p_O^U} (p_O^U - c^T) N^U, \ \frac{p_O^U}{b^U} \leq \alpha \end{cases}$$

The pricing equation and the profit function can be derived accordingly:[16]

$$p_O^U = \begin{cases} (\alpha + 1) b^U, \ \frac{p_O^U}{b^U} \geq \alpha + 1 \\ \frac{1}{2}[(\alpha + 1) b^U + c^T], \ \frac{p_O^U}{b^U} \in (\alpha, \alpha + 1) \\ \alpha b^U, \ \frac{p_O^U}{b^U} \leq \alpha \end{cases} \tag{34}$$

$$\pi_O^I = \begin{cases} 0, \ \frac{p_O^U}{b^U} \geq \alpha + 1 \\ \frac{1}{4b^U}[(\alpha + 1) b^U - c^T]^2 N^U, \ \frac{p_O^U}{b^U} \in (\alpha, \alpha + 1) \\ (\alpha b^U - c^T) N^U, \ \frac{p_O^U}{b^U} \leq \alpha \end{cases} \tag{35}$$

Under the cooperation, each firm shares part of π_O^I, i.e., U and T get π_O^U and π_O^T, respectively, and $\pi_O^U + \pi_O^T = \pi_O^I$. Let us denote the firms' payoffs under the Nash equilibrium of the first stage non-cooperative game by (π_N^U, π_N^T). If the bargain fails, U and T's payoffs become π_N^U and π_N^T, respectively. As presented by Nash (1953), the problem here can be formulated as:

$$max(\pi_O^U - \pi_N^U)^\gamma (\pi_O^T - \pi_N^T)^{1-\gamma} \quad s.t. \quad \pi_O^U + \pi_O^T = \pi_O^I$$

[16] Similar to Case 1 and Case 2 in Section 2.2, any $p_O^U \geq (\alpha + 1) b^U$ gives the same result.

$\gamma \in (0,1)$ is the parameter which accounts for an asymmetric Nash solution to capture some imprecisely defined differences in bargaining power.[17] The solution to the above question is:

$$\pi_O^U = \gamma \cdot (\pi_O^I - \pi_N^T) + (1-\gamma) \cdot \pi_N^U \tag{36}$$

$$\pi_O^T = \gamma \cdot \pi_N^T + (1-\gamma) \cdot (\pi_O^I - \pi_N^U) \tag{37}$$

Lemma 2.3.1

The second stage bargaining game succeeds if and only if $\pi_N^U + \pi_N^T < \pi_O^I$.

Proof:

The bargain succeeds if and only if both firms are better off under the cooperation, i.e., $\pi_O^U > \pi_N^U$ and $\pi_O^T > \pi_N^T$. Thus, we want to prove that $\pi_O^U > \pi_N^U$ and $\pi_O^T > \pi_N^T$ holds if and only if $\pi_N^U + \pi_N^T < \pi_O^I$. Since $\pi_O^U = \gamma(\pi_O^I - \pi_N^T) + (1-\gamma)\pi_N^U$, $\gamma(\pi_O^I - \pi_N^T) + (1-\gamma)\pi_N^U - \pi_N^U = \gamma(\pi_O^I - \pi_N^U - \pi_N^T) > 0$ if and only if $\pi_0^I > \pi_N^T + \pi_N^U$. Since $\pi_O^T = \gamma\pi_N^T + (1-\gamma)(\pi_O^I - \pi_N^U)$, $\gamma\pi_N^T + (1-\gamma)(\pi_O^I - \pi_N^U) - \pi_N^T = (1-\gamma)(\pi_O^I - \pi_N^U - \pi_N^T) > 0$ if and only if $\pi_O^I > \pi_N^T + \pi_N^U$. **Q.E.D.**

Lemma 2.3.1 shows that although the coefficient $\gamma \in (0,1)$ determines the allocation of π_O^I between the two firms, it will not determine the outcome of the bargain.

[17] Larger γ represents higher bargaining power for U. See Binmore, Rubinstein, and Wolinksy(1986).

Table 2-1 Possible Market Outcomes and Firm's Outside Options

U / T	OEM	OBM	Exit
Outsourcing	Cooperation	-	-
OBM	-	(1) Two monopolists in two markets (2) T enters but does not compete with U (3) Duopoly (Fight)	U alone
Exit	-	T alone	None

Figure 2-2 The Utility and the Demand

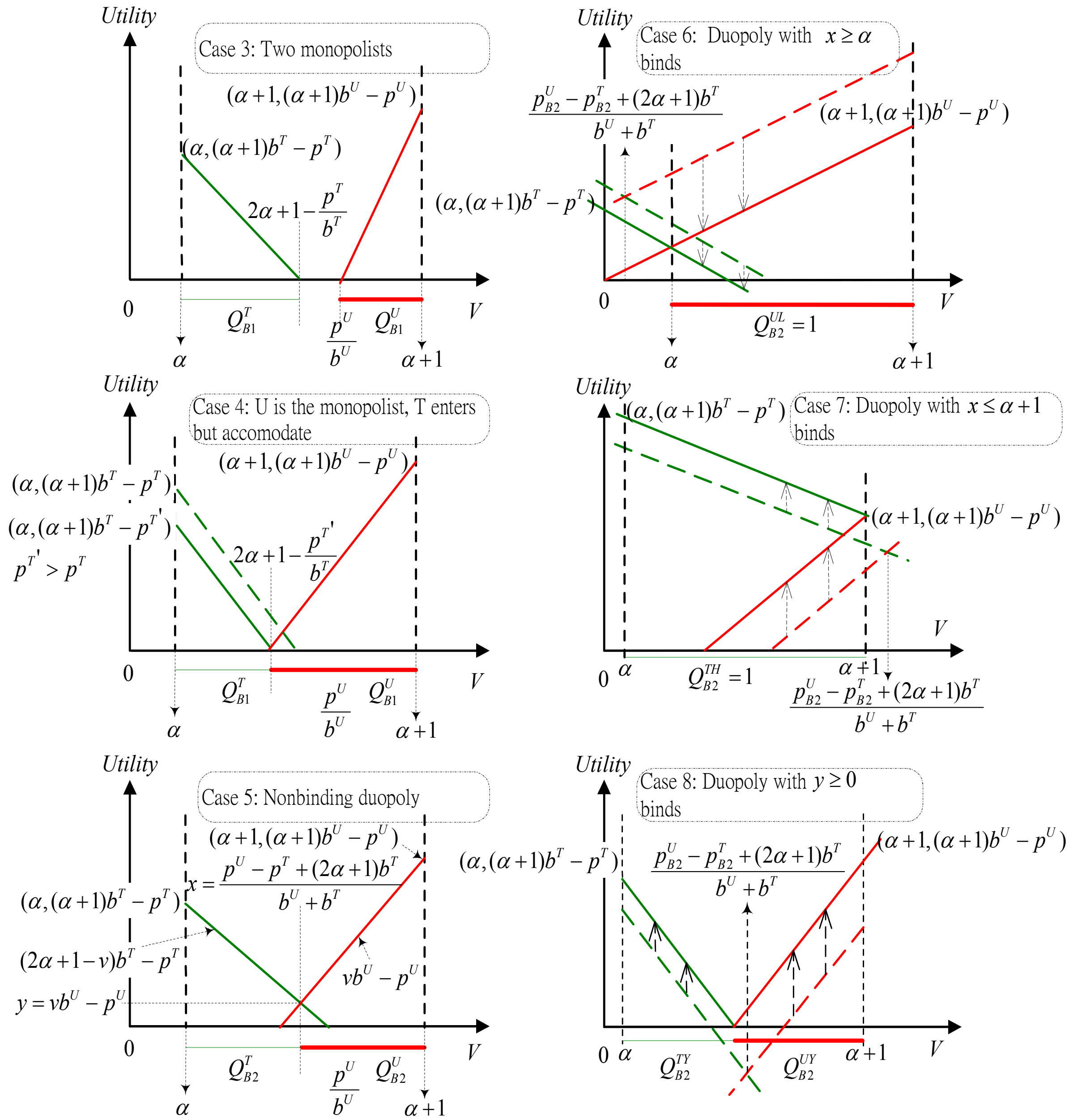
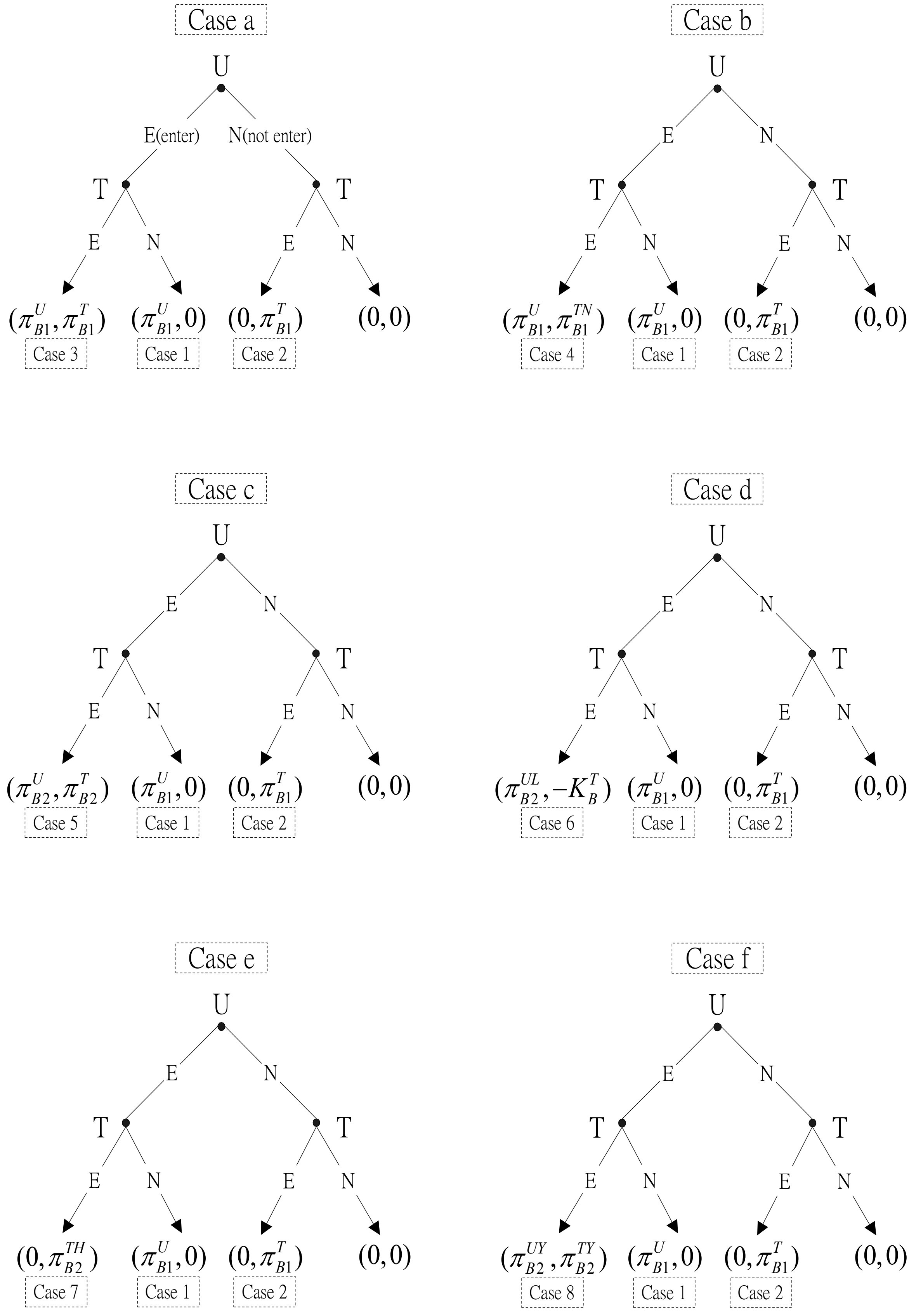


Figure 2-3 The Extensive Form Representation of the First-Stage Game[18]



[18] There are six possible outcomes if the two firms both enter, as discussed in Section 2.1.

3 Analysis

In section 3.1, Proposition 3.1.1 shows that if the brands are only vertically differentiated with $b^U > b^T$ and $c^U > c^T$, the bargain always succeeds. Proposition 3.1.2 shows that if the brands are both vertically and horizontally differentiated with $b^U > b^T$ and $c^U > c^T$, when the Nash equilibrium in the first stage game is such that only one firm enters, the bargain always succeeds. Finally, Proposition 3.1.3 shows that under the same premises as those for Proposition 3.1.2, the bargain could fail under some circumstances. The numerical examples are demonstrated in section 3.2.

3.1 Implication of the Model

Proposition 3.1.1

For the two-firm Nash bargaining problem with only vertically differentiated brands, if $b^U > b^T$, $c^U > c^T$, *and* $K_B^T \geq 0$, *then* $\pi_N^U + \pi_N^T < \pi_O^I$, *i.e., the bargain always succeeds, or, equivalently, if the bargain fails, then* $K_B^T < 0$.

Proof:

First, let us prove the existence of a unique Nash equilibrium in the first stage non-cooperative game. With only vertical differentiation, the two firms have the same horizontal location. If T enters, then either it cannot steal any customers from U or it triggers a duopoly competition. In the first case, T will not enter since its profit when entering is non-positive ($-K_B^T \leq 0$). The Nash equilibrium becomes (Enter, Not enter). In the second case, the final outcome depends on T's duopoly profit $\pi_{B2}^{T'}$. If $\pi_{B2}^{T'} > 0$, the Nash equilibrium is (Enter, Enter). Otherwise it is (Enter, Not enter).

Now, let us prove that if $b^U > b^T$, $c^U > c^T$, and $K_B^T \geq 0$, then $\pi_N^U + \pi_N^T < \pi_O^I$. First, suppose that each firm has its opponent's advantage, i.e., U has $c^U = c^T$ and T has $b^T = b^U$. Then, the highest total industrial profit can be attained if the two OBM firms collude. If $K_B^T = 0$, this profit is equal to the total industrial profit under the cooperation, i.e., π_O^I, since π_O^I can be regarded as the monopoly profit under the combination of b^U and c^T. Thus, we have $\pi_C^U + \pi_C^T = \pi_O^I$. ($\pi_C^U$ and π_C^T denote U's and T's collusive profits when $c^U = c^T$, $b^T = b^U$, and $K_B^T = 0$). On the contrary, when $b^U > b^T$, $c^U > c^T$, $K_B^T \geq 0$, and the two firms do engage in price competition, we must have $\pi_N^U < \pi_C^U$ and $\pi_N^T < \pi_C^T$. Thus, $\pi_N^U + \pi_N^T < \pi_C^U + \pi_C^T = \pi_O^I$. **Q.E.D.**

Proposition 3.1.1 shows that the higher brand value from U and the lower production cost from T is the best combination to attain the highest total industrial profit. This implies that if T's brand cannot be horizontally differentiated (or, equivalently, if T's OBM product cannot be horizontally differentiated), it will always choose to cooperate with U, i.e., be the subcontractor of U. It is straightforward to show that T must be "over-subsidized" to become an OBM firm in this case.[19]

Proposition 3.1.2

For the two-firm Nash bargaining problem with both vertically and horizontally differentiated brands, suppose U and T locate at $\alpha + 1$ *and* α*, respectively* ($\alpha \geq 0$), $b^U > b^T$, $c^U > c^T$, *and* $K_B^T \geq 0$. *If the Nash equilibrium in the first stage game is that only one firm enters, then* $\pi_N^U + \pi_N^T < \pi_O^I$ *always holds, i.e., the bargain always succeeds, or equivalently, if the bargain fails, then the Nash equilibrium in the first stage game must be that both firms enter.*

Proof:

The idea is similar to Proposition 3.1.1. If the Nash equilibrium in the first stage game is such that only U enters, then its production cost is higher than that of T. Similarly, if the Nash equilibrium in the first stage game is such that only T enters, then its brand value is lower than that of U, and T has to incur a nonnegative sunk cost K_B^T in branding. Both cases imply that the cooperation can yield a higher total industrial profit.[20] **Q.E.D.**

[19] Here, "over-subsidization" means that the amount of the subsidy must be greater than the sunk cost K_B^T.

[20] Note that if only one OBM firm exists or if the two firms cooperate, there is only one product in the market.

Proposition 3.1.3

For the two-firm Nash bargaining problem with both vertically and horizontally differentiated brands such that U, T locate at $\alpha + 1$ *and* α*, respectively* ($\alpha \geq 0$), $b^U > b^T$, $c^U > c^T$, *and* $K_B^T \geq 0$, *if* b^T *is high enough and* K_B^T *is low enough, then* $\pi_N^U + \pi_N^T < \pi_O^I$ *does not always hold, i.e., the bargain might fail.*

The proof is in Appendix A-04. It shows that T might become an OBM firm when its brand value gets higher and the sunk cost to brand gets lower.

3.2 Numerical Examples

This section demonstrates the numerical examples to show the argument presented in Proposition 3.1.3, i.e., that the bargain might fail. The program is written in GAMS and consists of two parts. The first part is to calculate the prices, quantities, and profits under different cases as discussed in Section 2.2. The second part is to solve the two-stage game given the information from the first part. The flow chart for the program is presented in Appendix A-05.

The benchmark is characterized by $\{b^U, b^T, c^U, c^T, N^U, K_B^T, \alpha\} = \{20, 1.9, 2, 1, 1, 0, 0\}$. The simulations change the following parameters: $b^T \in [1.9, 19.9]$, $K_B^T \in [0, 18]$, and $\alpha = 0, 1, 5$. Note that the paper only considers $b^U > b^T > 0$ and $0 < c^T < b^U$. Also, the change in α will change both the intensity of the preference and the relative distance of the two products. When α is large, the consumer with the least preference for a particular brand still values it rather highly. At the same time, although the absolute distance between the two firms is always unity, the relative horizontal differentiation between the two products decreases.

Thus, when α increases, the "intensity effect" encourages T to be an OBM firm. However, the "relative distance effect" discourages T to do so since the relative horizontal distance diminishes. For a moderate level of α, T is more likely to be an OBM firm due to the dominance of the intensity effect. However, when $\alpha \to \infty$, T will not choose to be an OBM firm since the relative distance effect dominates. These cases will be demonstrated in the following simulations.

Figure 3-1 considers the case with $\alpha = 0$. The Nash equilibrium of the first stage game is represented by different colors while the final outcome of the bargain is determined by the number in the corresponding cell, which represents the value for $\pi_O^I - (\pi_N^U + \pi_N^T)$. Thus, a positive number means a successful bargain while a negative one means a failed bargain. Let us first consider the outside options. Note that when $\alpha = 0$, if both firms do enter the final goods market, they are two monopolists in two separate markets. The simulation shows that the higher sunk cost in branding (K_B^T) discourages T from entering the market. On the other hand, if T's brand value (b^T) gets higher, it is more likely to be an OBM firm. Second, for the final outcome of the bargain, the simulation shows that the higher K_B^T favors a successful bargain while the higher b^T discourages the cooperation (thus encourages T to brand). The simulation also demonstrates Proposition 3.1.2, i.e., if T's outside option is not to be an OBM firm, the bargain always succeeds.

Figure 3-2 presents the simulation with $\alpha = 1$. For both the outside options and the final outcome, the patterns are similar to those with $\alpha = 0$. For the outside options, given a wide range of K_B^T, when b^T is small, the Nash equilibrium of the first stage game is such that U is the monopolist and T does not enter. When b^T is moderate, the equilibrium becomes a binding duopoly. Finally, when b^T is large enough, the equilibrium will be "U is the monopolist since T enters but does not fight". Note that when b^T is smaller, T has to lower its price to attract the consumer, which means a duopolistic competition is more likely to be triggered. For the final outcome, the bargain is more likely to fail compared to that with $\alpha = 0$. This suggests that the intensity effect dominates.

Figure 3-3 presents the simulation with $\alpha = 5$. The evolution of the outside options is similar to the previous simulations. Note that larger α makes both the intensity effect and the relative distance effect stronger. The intensity effect pushes both $u = vb^U - p^U$ and $u = (2\alpha + 1 - v)b^T - p^T$ upward. If α is large enough, each firm will occupy the whole market when it enters alone. This suggests that larger α is more likely to trigger the duopolistic competition if T decides to enter.[21] Thus, the relative distance effect gradually dominates since the relative horizontal differentiation between the two products diminishes. Note that the valuation of U's product is uniformly distributed in $[\alpha b^U - p^U, (\alpha+1)b^U - p^U]$. When α is large enough, the difference between $\alpha b^U - p^U$ and $(\alpha+1)b^U - p^U$, which is just b^U, becomes relatively small compared to α. This means that the consumer with the lowest valuation of U's product still values it rather highly. Now, if $\alpha b^U - p^U > (\alpha+1)b^T - p^T$, U's product strictly dominates T's product for every consumer. Thus, the Nash equilibrium in the first stage game will be $(Enter, Not\ enter)$. On the other hand, if $b^T < b^U$ but $b^T \to b^U$ so that T's product is not strictly dominated and the Nash equilibrium in the first stage game results in a duopoly, the relatively smaller horizontal differentiation as α gets larger means that the price competition between the two OBM products becomes fiercer. This implies that cooperating and sharing the monopoly profit might be a better choice for both parties. This is also demonstrated in Figure 3-3.

[21] It can be verified that the intersection of $u = vb^U - p^U$ and $u = (2\alpha + 1 - v)b^T - p^T$ under the nonbinding duopoly prices, denoted by (x, y), moves upward as α gets larger.

Figure 3-1 K_B^T vs b^T ($\alpha = 0$) $\{b^U, b^T, c^U, c^T, N^U, K_B^T, \alpha\} = \{20, 1.9{\sim}19.9, 2, 1, 1, 0{\sim}18, 0\}$

	b^T	1.9	2.8	3.7	4.6	5.5	6.4	7.3	8.2	9.1	10.0	10.9	11.8	12.7	13.6	14.5	15.4	16.3	17.2	18.1	19.0	19.9
K_B^T																						
0.0		0.4	0.2	0.0	**-0.2**	**-0.5**	**-0.7**	**-0.9**	**-1.1**	**-1.3**	**-1.6**	**-1.8**	**-2.0**	**-2.2**	**-2.5**	**-2.7**	**-2.9**	**-3.1**	**-3.4**	**-3.6**	**-3.8**	**-4.0**
0.9		0.5	0.5	0.5	0.5	0.4	0.2	0.0	**-0.2**	**-0.4**	**-0.7**	**-0.9**	**-1.1**	**-1.3**	**-1.6**	**-1.8**	**-2.0**	**-2.2**	**-2.5**	**-2.7**	**-2.9**	**-3.1**
1.8		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.2	0.0	**-0.2**	**-0.4**	**-0.7**	**-0.9**	**-1.1**	**-1.3**	**-1.6**	**-1.8**	**-2.0**	**-2.2**
2.7		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.2	0.0	**-0.2**	**-0.4**	**-0.7**	**-0.9**	**-1.1**	**-1.3**
3.6		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.2	0.0	**-0.2**	**-0.4**
4.5		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5.4		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6.3		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
7.2		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
8.1		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
9.0		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
9.9		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
10.8		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
11.7		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
12.6		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
13.5		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
14.4		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
15.3		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
16.2		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
17.1		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
18.0		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Outside option: **White**-only U. **Light gray**-two monopolists enter in two separate markets.
Final result: **Number in the cell** = $\pi_O^I - (\pi_N^U + \pi_N^T)$ $\therefore$ Non-positive if and only if the bargain fails.

Figure 3-2 K_B^T vs b^T ($\alpha = 1$) $\{b^U, b^T, c^U, c^T, N^U, K_B^T, \alpha\} = \{20, 1.9{\sim}19.9, 2, 1, 1, 0{\sim}18, 1\}$

	b^T	1.9	2.8	3.7	4.6	5.5	6.4	7.3	8.2	9.1	10.0	10.9	11.8	12.7	13.6	14.5	15.4	16.3	17.2	18.1	19.0	19.9
K_B^T																						
0.0		0.8	0.6	0.3	0.1	**-0.2**	**-0.5**	**-0.9**	**-1.3**	**-1.7**	**-2.2**	**-2.7**	**-3.2**	**-3.7**	**-4.3**	**-4.9**	**-13.4**	**-14.3**	**-15.2**	**-16.1**	**-17.0**	**-17.9**
0.9		1.0	1.0	1.2	1.0	0.7	0.4	0.0	**-0.4**	**-0.8**	**-1.3**	**-1.8**	**-2.3**	**-2.8**	**-3.4**	**-4.0**	**-12.5**	**-13.4**	**-14.3**	**-15.2**	**-16.1**	**-17.0**
1.8		1.0	1.0	1.0	1.9	1.6	1.3	0.9	0.5	0.1	**-0.4**	**-0.9**	**-1.4**	**-1.9**	**-2.5**	**-3.1**	**-11.6**	**-12.5**	**-13.4**	**-14.3**	**-15.2**	**-16.1**
2.7		1.0	1.0	1.0	1.0	1.0	2.2	1.8	1.4	1.0	0.5	0.0	**-0.5**	**-1.0**	**-1.6**	**-2.2**	**-10.7**	**-11.6**	**-12.5**	**-13.4**	**-14.3**	**-15.2**
3.6		1.0	1.0	1.0	1.0	1.0	1.0	2.7	2.3	1.9	1.4	0.9	0.4	**-0.1**	**-0.7**	**-1.3**	**-9.8**	**-10.7**	**-11.6**	**-12.5**	**-13.4**	**-14.3**
4.5		1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.2	2.8	2.3	1.8	1.3	0.8	0.2	**-0.4**	**-8.9**	**-9.8**	**-10.7**	**-11.6**	**-12.5**	**-13.4**
5.4		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	3.7	3.2	2.7	2.2	1.7	1.1	0.5	**-8.0**	**-8.9**	**-9.8**	**-10.7**	**-11.6**	**-12.5**
6.3		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	4.1	3.6	3.1	2.6	2.0	1.4	**-7.1**	**-8.0**	**-8.9**	**-9.8**	**-10.7**	**-11.6**
7.2		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	4.5	4.0	3.5	2.9	2.3	**-6.2**	**-7.1**	**-8.0**	**-8.9**	**-9.8**	**-10.7**
8.1		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	4.9	4.4	3.8	3.2	**-5.3**	**-6.2**	**-7.1**	**-8.0**	**-8.9**	**-9.8**
9.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	5.3	4.7	4.1	**-4.4**	**-5.3**	**-6.2**	**-7.1**	**-8.0**	**-8.9**
9.9		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	5.6	5.0	**-3.5**	**-4.4**	**-5.3**	**-6.2**	**-7.1**	**-8.0**
10.8		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	5.9	**-2.6**	**-3.5**	**-4.4**	**-5.3**	**-6.2**	**-7.1**
11.7		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	**-1.7**	**-2.6**	**-3.5**	**-4.4**	**-5.3**	**-6.2**
12.6		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	**-0.8**	**-1.7**	**-2.6**	**-3.5**	**-4.4**	**-5.3**
13.5		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.1	**-0.8**	**-1.7**	**-2.6**	**-3.5**	**-4.4**
14.4		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.1	**-0.8**	**-1.7**	**-2.6**	**-3.5**
15.3		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.1	**-0.8**	**-1.7**	**-2.6**
16.2		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.1	**-0.8**	**-1.7**
17.1		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.1	**-0.8**
18.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.1

Outside option: **White**-only U. **Light gray**-U monopolist; T enters but not fight. **Dark gray**-Duopoly with $v \geq 0$ binds.
Final result: **Number in the cell** = $\pi_O^I - (\pi_N^U + \pi_N^T)$ $\therefore$ Non-positive if and only if the bargain fails.

Figure 3-3 K_B^T vs b^T ($\alpha = 5$) $\{b^U, b^T, c^U, c^T, N^U, K_B^T, \alpha\} = \{20, 1.9{\sim}19.9, 2, 1, 1, 0{\sim}18, 5\}$

	b^T	1.9	2.8	3.7	4.6	5.5	6.4	7.3	8.2	9.1	10.0	10.9	11.8	12.7	13.6	14.5	15.4	16.3	17.2	18.1	19.0	19.9
K_B^T																						
0.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	48.9	53.4	57.2	60.6	63.4	65.8	67.8	69.3	70.6	71.5	72.1	72.4	72.4	72.2
0.9		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	58.1	61.5	64.3	66.7	68.7	70.2	71.5	72.4	73.0	73.3	73.3	73.1
1.8		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	65.2	67.6	69.6	71.1	72.4	73.3	73.9	74.2	74.2	74.0
2.7		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	68.5	70.5	72.0	73.3	74.2	74.8	75.1	75.1	74.9
3.6		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	71.4	72.9	74.2	75.1	75.7	76.0	76.0	75.8
4.5		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	72.3	73.8	75.1	76.0	76.6	76.9	76.9	76.7
5.4		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	74.7	76.0	76.9	77.5	77.8	77.8	77.6
6.3		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	76.9	77.8	78.4	78.7	78.7	78.5
7.2		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	77.8	78.7	79.3	79.6	79.6	79.4
8.1		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	79.6	80.2	80.5	80.5	80.3
9.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	81.1	81.4	81.4	81.2
9.9		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	82.0	82.3	82.3	82.1
10.8		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	83.2	83.2	83.0
11.7		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	84.1	84.1	83.9
12.6		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	85.0	84.8
13.5		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	85.9	85.7
14.4		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	86.6
15.3		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	87.5
16.2		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
17.1		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
18.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Outside option: **White**-only U. **Light gray**-Nonbinding duopoly.
Final result: **Number in the cell** = $\pi_O^I - (\pi_N^U + \pi_N^T)$ ∴ Non-positive if and only if the bargain fails.

4 Empirical Evidence

Proposition 3.1.1 argues that if the brands are only vertically differentiated, without any subsidies, the Taiwanese subcontractor will not brand. This suggests that if the Taiwanese subcontractor decides to become an OBM firm, it should horizontally differentiate its brand (or product) from the incumbent, if possible.[22] Since the level of horizontal differentiation is difficult to measure, 4.1 simply provides anecdotal evidence that demonstrates firms' strategies in horizontal differentiation.[23]

Proposition 3.1.3 argues that with horizontal differentiation, when the brand value and sunk cost to brand for the Taiwanese subcontractor are high and low enough, respectively, the subcontractor might brand. This is confirmed by the numerical examples in 3.2 and will be tested empirically in 4.2.

4.1 Case Studies for Horizontal Differentiation

Many examples reveal that OBM firms would like to horizontally differentiate their products. HTC, one of the few Taiwanese cell phone subcontractors that has recently begun to sell its own-brand products, produced around 11 million cell phones in 2007. Over 70% of HTC's products are OBM products, most of which are sold in Europe. HTC's key strategy is to horizontally differentiate its "smart phone" from other cell phone products and focus on those consumers who are "using mobile devices for much more than voice calls and text messages."[24]

It is very common for OBM firms to differentiate their products by focusing on a specific group of consumers who might have different tastes from consumers elsewhere. For instance, INVENTEC, another Taiwanese cell phone maker, has emphasized that its goal is to become the local branding

[22] This paper assumes that product differentiation can also result in brand differentiation. For a new branding firm, this seems reasonable since the consumer's main impression of its brand might come from its products. Thus, in this paper, product differentiation is both necessary and sufficient for brand differentiation.

[23] Strauss (2002) uses the geographical coverage of a firm's product as an index of the level of horizontal differentiation. This treatment, however, would not be compatible to the notion of horizontal differentiation discussed in this paper. Since in this paper, the notion of horizontal differentiation corresponds to a distribution of consumers with different preferences.

[24] See BusinessWeek 11/8/2007.

firm that specifically meets users' needs in the Chinese market.[25] Similarly, Genius, a scanner and computer peripherals manufacturer, only sells OBM products domestically and in developing countries.

If the subcontractors decide to brand, they are likely to turn the outsourcing firms from customers into competitors, especially when the products are similar from the consumers' point of view. Furthermore, if firms choose to be both subcontractors and OBM firms simultaneously, the outsourcing firms will worry about technology spillovers into the new OBM firms through subcontracting.

In fact, daily news has shown that subcontractors lose outsourcing orders when they decide to become OBM firms and manufacture products similar to those sold by the outsourcing firms, which are their current customers. This could explain why many Taiwanese manufacturers still focus solely on subcontracting markets. For example, in 2007, Quanta Computer and Compal Electronics produced approximately 30 million and 23 million laptops, respectively, and accounted for over half of the world's laptop output; however, they choose to remain pure OEM/ODM manufacturers.[26]

Despite this tension, many Taiwanese firms still choose to be OBM firms and subcontractors simultaneously. In this case, they often try to horizontally differentiate their products from the foreign outsourcing firms'. Furthermore, in response to outsourcing firms' concerns, those Taiwanese firms might even split their individual companies into two, such that one becomes a pure OBM firm and the other becomes a pure OEM/ODM firm. One example is ACER, which has split up into Wistron (a pure OEM/ODM firm) and ACER (a pure OBM firm).

4.2 Evidence for Firms' Branding Statuses in Different Markets

[25] Both firms (HTC and INVENTEC) are still subcontractors to other branding firms. However, HTC's main business (70% to 80% of the global sales) is selling its OBM products, while for INVENTEC, more than 85% of its global sales are from ODM or OEM products. For INVENTEC, limiting OBM products to local markets prevents competition with the outsourcing firms.

[26] Compal computer does sell a few own-brand laptops in the domestic market. However, more than 95% of its output is OEM/ODM products (See Appendix A-06).

To test Proposition 3.1.3, this paper derives a prediction of firms' branding statuses in different markets from that proposition, then it investigates the branding statuses of Taiwanese subcontractors in three different markets: 1) Taiwan; 2) China or developing countries; and 3) developed countries.

To derive a testable hypothesis, besides simply considering the U.S. market as in Section 2, let us consider the scenario that U is the incumbent branding firm in the aforementioned three markets, while T decides whether it should brand in these markets.

Let us denote T's brand values in the aforementioned three markets by b_T^T, b_C^T, and b_U^T, respectively, and denote the corresponding sunk costs to brand by K_{BT}^T, K_{BC}^T, and K_{BU}^T, respectively. Since for Taiwanese firms, it would be much easier to promote their products domestically, let us assume that $b_T^T > b_C^T > b_U^T$. Furthermore, since the sunk cost to brand is likely to positively correlate with the market size, let us assume that $K_{BT}^T < K_{BC}^T < K_{BU}^T$. Finally, let us assume that T's brand is both vertically and horizontally differentiated from U's brand in all markets. Under these assumptions, this paper proposes the following hypothesis:

Hypothesis 4.2.1

Taiwanese firms are more likely to brand domestically. They would have a harder time extending their brands to China or other developing countries, and they would have the most difficulty branding in developed countries.

To test Hypothesis 4.2.1, this paper takes the Taiwanese listed companies in the "3C" industries (Computer, Communication, and Consumer Electronics) as an example. Based on the roster compiled by the Taiwan Economic Journal, the author collects and expands the dataset from each firm's website and the relevant news reports. Since the main focus is on firms that produce the final goods, those producing the intermediate goods or targeting business users will not be included.

This paper examines 2007 data for 92 observations (firms[27]) with their branding statuses in 1) Taiwan; 2) China or other developing countries; and 3) developed countries. These observations include: 1) 8 desktop manufacturers; 2) 15 laptop manufacturers; 3) 14 monitor manufacturers; 4) 11 scanner and multi-purpose printer manufacturers; 5) 12 cell phone manufacturers; and 6) 32 consumer electronics manufacturers.[28] Appendix A-06 presents details of the sample.

While not every firm's OEM or ODM share can be ascertained, A-06 shows that for the 92 firms, 34 are pure subcontractors while at least 45 have OEM/ODM output that accounts for 50% or more of the business. The data reveal that subcontracting businesses are crucial to Taiwanese firms in "3C" industries. This phenomenon conforms to the aggregate data presented in Chu (2006) (see Table 1-1).

Table 4-1, which summarizes each observation's branding status from A-06, demonstrates the preliminary evidence in favor of Hypothesis 4.2.1. First, while 52 firms brand domestically, only 44 firms sell their OBM products in China or other developing countries, and only 31 do so in developed countries. Another interesting pattern is that observations not branding in Taiwan also do not brand in China or other developing countries. Furthermore, those not branding in China or other developing countries also do not brand in developed countries.

Let us test whether there are discernible differences among firms' branding statuses in all the three different markets. Let us denote the proportions of firms that brand in Taiwan, China or developing countries, and developed countries by μ_T, μ_C, and μ_D, respectively. The hypothesis test is:

$$\mathrm{H_0}: \mu_T = \mu_C = \mu_D$$

$$\mathrm{H_a}: \mathrm{H_0} \text{ is not true.}$$

This paper uses a two-way ANOVA to test the hypothesis since the available data in Table 4-1 allow this study to decompose the total variation of firms' branding statuses into: 1) the variation due

[27] Note that for the 92 observations, 44 are out of 16 conglomerates, which means that the 92 observations are from only 64 conglomerates. A conglomerate (or a firm) might choose to be a pure subcontractor that produces laptops while selling phones with its brand. In this case, the single conglomerate will generate two observations. The correlation between the conglomerate's branding strategies in different products is beyond the scope of this paper. For simplicity, this paper will just name each observation a firm.

[28] They include audio system, digital camera/video, household appliances, and GPS.

to the factor “market”; and 2) the variation due to the factor “firm”. For simplicity, let us assume that there is no interaction between these two factors.[29] The result shown in Table 4-2 provides clear evidence to reject the null at a 1% significance level.

Next, this paper tests for those firms which have already branded in Taiwan, are they more likely to brand in China or developing countries than to brand in developed countries? Let us denote the proportions of the domestic branding firms that brand in China/developing countries and developed countries by $\mu_{C|BT}$ and $\mu_{D|BT}$, respectively. The hypothesis test can be expressed as:

$$\mathrm{H_0}: \mu_{C|BT} \leq \mu_{D|BT}$$

$$\mathrm{H_a}: \mu_{C|BT} > \mu_{D|BT}.$$

Table 4-3 shows that for the 52 firms that have branded domestically, 44 firms also brand in China or developing countries, which account for 84.62% of the domestic OBM firms, while only 31 brand in developed countries, which account for merely 59.62% of the domestic OBM firms. It also shows the result from the matched pair t-test. Since the p-value is less than 1%, the result provides strong evidence which demonstrates that Taiwanese domestic branding firms are more likely to brand in China or developing countries rather than in developed countries.

Finally, to find the evidence that sufficiently supports the argument of Hypothesis 4.2.1, i.e., $\mu_T > \mu_C > \mu_D$, let us set up the following test:

$$\mathrm{H_0}: \mu_T \leq \mu_C \ or \ \mu_C \leq \mu_D$$

$$\mathrm{H_a}: \mu_T > \mu_C > \mu_D.$$

The test can be carried out by having two separate t-tests $\mathrm{H_0}: \mu_T \leq \mu_C \ \mathrm{v.s.} \ \mathrm{H_a}: \mu_T > \mu_C$ and $\mathrm{H_0}: \mu_C \leq \mu_D \ \mathrm{v.s.} \ \mathrm{H_a}: \mu_C > \mu_D$ and then use the Bonferroni correction[30] to account for the overall

[29] See p.336-341 in Wonnacott and Wonnacott (1990).

[30] Let $\mathrm{E_1}$ and $\mathrm{E_2}$ denote the event of making type I error in the two separate tests such that $\mathrm{P(E_1)} = \alpha_1$ and $\mathrm{P(E_2)} = \alpha_2$ (α_1 and α_2 are probabilities of making type I error in the two separate tests, respectively). Since the event of type I error in the joint test is $\mathrm{E_1} \cup \mathrm{E_2}$, the probability of making type I error in the joint test is $\mathrm{P(E_1 \cup E_2)}$. Note that $\mathrm{P(E_1 \cup E_2)} = \mathrm{P(E_1)} + \mathrm{P(E_2)} - \mathrm{P(E_1 \cap E_2)} \leq \mathrm{P(E_1)} + \mathrm{P(E_2)}$. As a result, the size of

size the joint test.[31] Note that to reject H_0, one should be able to reject the null hypotheses in the two separate t-tests simultaneously. The results in Table 4-4 support the argument of $\mu_T > \mu_C > \mu_D$ (under 1% significance level). This confirms Hypothesis 4.2.1.

the joint test will not be greater than the sum of the sizes of the two separate t-tests. The Bonferroni correction is just the above procedure that derives the upper bound of the size of the joint test from the sizes of the separate tests. See p.230 in Cameron and Trivedi (2005).

[31] Note that since the observations in Table 4-1 are matched sample, these t-tests should be matched sample t-tests.

Table 4-1 Branding Statuses of the Observations (Branding = 1; Not branding = 0)[32]

Obs#	TW	CN/DEVING	DEVED	Obs#	TW	CN/DEVING	DEVED
1	1	1	1	47	0	0	0
2	0	0	0	48	1	1	1
3	1	1	1	49	0	0	0
4	1	1	1	50	1	1	1
5	1	0	0	51	1	1	0
6	1	0	0	52	0	0	0
7	1	0	0	53	1	0	0
8	1	1	0	54	0	0	0
9	1	1	1	55	1	1	0
10	0	0	0	56	1	1	1
11	1	1	0	57	1	1	0
12	0	0	0	58	0	0	0
13	0	0	0	59	0	0	0
14	1	1	1	60	1	1	0
15	0	0	0	61	0	0	0
16	1	1	1	62	1	1	1
17	1	1	1	63	1	1	1
18	1	0	0	64	0	0	0
19	0	0	0	65	0	0	0
20	1	0	0	66	1	1	1
21	1	1	0	67	1	0	0
22	0	0	0	68	0	0	0
23	0	0	0	69	1	1	1
24	1	1	1	70	0	0	0
25	0	0	0	71	1	0	0
26	0	0	0	72	0	0	0
27	0	0	0	73	1	1	1
28	0	0	0	74	1	1	0
29	1	1	1	75	1	1	1
30	0	0	0	76	0	0	0
31	1	1	0	77	1	1	1
32	0	0	0	78	0	0	0
33	1	1	1	79	1	1	0
34	1	1	1	80	0	0	0
35	0	0	0	81	1	1	1
36	0	0	0	82	0	0	0
37	0	0	0	83	1	1	1
38	1	1	0	84	1	1	1
39	0	0	0	85	1	1	1
40	1	1	0	86	1	1	1
41	1	1	1	87	0	0	0
42	1	1	1	88	1	1	1
43	1	1	1	89	1	1	0
44	1	1	1	90	0	0	0
45	0	0	0	91	0	0	0
46	0	0	0	92	0	0	0

[32] See the details in Appendix A-06. Here are the notations: TW=Taiwan; CN/DEVING=China or developing countries; DEVED=developed countries.

Table 4-2 Two-Way ANOVA for Firms' Branding Statuses in Different Markets

Source	SS	df	MS	F-statistic	p-value
Markets	2.44	2	1.22	19.23	< 0.01
Firms	54.56	91	0.60	9.44	< 0.01
Residual	11.56	182	0.06		
Total	68.56	275			

Table 4-3 Test for $\mathbf{H_0: \mu_{C|BT} \leq \mu_{D|BT}\ v.s.\ H_a: \mu_{C|BT} > \mu_{D|BT}}$

Firms that brand:	Number	% out of (A)	$\mu_{C\|BT} - \mu_{D\|BT}$
Domestically (A)	52	100.00%	
in CN/DEVING (B)	44	84.62%	
in DEVED (C)	31	59.62%	
Test for $\mu_{C\|BT} = \mu_{D\|BT}$			
t-statistic for			7.33
p-value			<0.01

Table 4-4 Joint t-test for $\mathbf{H_0: \mu_T \leq \mu_C\ v.s.\ H_a: \mu_T > \mu_C}$ and $\mathbf{H_0: \mu_C \leq \mu_D\ v.s.\ H_a: \mu_C > \mu_D}$

	$\mu_T - \mu_C$	$\mu_C - \mu_D$	Joint t-test*
t-statistic for	2.94	3.87	-
p-value	<0.005	<0.005	<0.01

*: The p-value for the joint t-test has been adjusted by Bonferroni correction.

5 Conclusion

This paper analyzes the interaction between a foreign outsourcing firm and a domestic subcontractor. It demonstrates that if the brands are only vertically differentiated, the subcontractor with the lower brand value will choose to cooperate with the outsourcing firm.

However, if 1) the brands are also horizontally differentiated; 2) the sunk cost to brand is low; and 3) the brand value for the potential branding firm is high enough, the subcontractor might choose to brand and enter the final goods market even without subsidies. This argument is confirmed by both the numerical simulations in 3.2 and the empirical evidence from Taiwan in 4.2.

In fact, the dilemma that this paper models seems to be quite common among the subcontractors in other NICs or developing countries who are considering whether to establish their own brands.

One might consider making the brand value on each product into another choice variable for the firm and then solving the maximization problem by backward induction. In this case, a common practice would be to normalize the production cost to zero to simplify the analysis.[33] However, this paper must take into account the different levels of production costs between the firms. Unfortunately, without the zero cost assumption, it becomes quite difficult to get a reduced form solution under the duopoly setting. Similarly, making the location into another choice variable for the firm also complicates the analysis a great deal.

While this paper does shed light on the interaction between a foreign outsourcing firm and a domestic subcontractor, such modeling could be further developed and refined. For example, the subcontracting markets are highly competitive in reality. For firms in NICs or developing countries, rather than being the subcontractors and competing with other OEM or ODM firms for meager profits, branding and then marketing the products directly seems to be a reasonable way to upgrade. This could also justify the subcontractors' choices to have their own brands.

[33] For example, see Motta (1993), Herguera et al. (2000), and Sanjo (2007).

Another extension would be to build a model where the brand value of the new entrant depends on its branding expenditure. Furthermore, one can establish a dynamic model that considers that the brand value on the product can become even higher than that for the incumbent in the long run. Consequently, the subcontractor's problem would be to maximize the present value of the profit. However, even if branding is profitable, the sunk cost to brand could be too high for the subcontractor to afford at the beginning if there is no way to finance the project. In this case, outside support (possibly subsidies) or an efficient financial market would be crucial.

Appendix

A-01 Profit Maximization for the Nonbinding Duopoly

The profit maximization problems are:

$$\pi_{B2}^{U} = max_{p_{B2}^{U}}(p_{B2}^{U} - c^{U})\left(\alpha + 1 - \frac{p_{B2}^{U} - p_{B2}^{T} + (2\alpha+1)b^{T}}{b^{U}+b^{T}}\right)N^{U}$$

$$\pi_{B2}^{T} = max_{p_{B2}^{T}}(p_{B2}^{T} - c^{T})\left(\frac{p_{B2}^{U} - p_{B2}^{T} + (2\alpha+1)b^{T}}{b^{U}+b^{T}} - \alpha\right)N^{U} - K_{B}^{T}$$

From $\frac{\partial \pi_{B2}^{T}}{\partial p_{B2}^{T}} = 0$, we can find T's reaction function: $p_{B2}^{T} = \frac{(\alpha+1)b^{T} + c^{T} - \alpha b^{U} + p_{B2}^{U}}{2}$. Plugging this into π_{B2}^{U}, we have:

$$\pi_{B2}^{U} = max_{p_{B2}^{U}}(p_{B2}^{U} - c^{U})\left(\alpha + 1 - \frac{p_{B2}^{U} - \frac{(\alpha+1)b^{T} + c^{T} - \alpha b^{U} + p_{B2}^{U}}{2} + (2\alpha+1)b^{T}}{b^{U}+b^{T}}\right)N^{U}$$

From $\frac{\partial \pi_{B2}^{U}}{\partial p_{B2}^{U}} = 0$, $(\alpha+1)(b^{U} + b^{T}) + \frac{(\alpha+1)b^{T} + c^{T} - \alpha b^{U}}{2} - (2\alpha+1)b^{T} + \frac{c^{U}}{2} = P_{B2}^{U}$. Rearranging terms, we can get:

$$p_{B2}^{U} = \frac{(\alpha+2)b^{U} + (-\alpha+1)b^{T} + c^{T} + c^{U}}{2}$$

Plugging p_{B2}^{U} into T's reaction function:

$$p_{B2}^{T} = \frac{(\alpha+1)b^{T} + c^{T} - \alpha b^{U} + \frac{(\alpha+2)b^{U} + (-\alpha+1)b^{T} + c^{T} + c^{U}}{2}}{2} = \frac{(\alpha+3)b^{T} + (-\alpha+2)b^{U} + 3c^{T} + c^{U}}{4}$$

A-02 Profit Maximization for the Binding Duopoly with $\mathbf{y \geq 0}$ Binding

U's profit maximization problem becomes:

$$\pi_{B2}^{UY} = max_{p_{B2}^{UY}}(p_{B2}^{UY} - c^{U})\left(\alpha + 1 - \frac{p_{B2}^{UY} - p_{B2}^{TY} + (2\alpha+1)b^{T}}{b^{U}+b^{T}}\right)N^{U}$$

$$s.t.\ \ p_{B2}^{TY} = \frac{(\alpha+1)b^{T} + c^{T} - \alpha b^{U} + p_{B2}^{UY}}{2}\ \ and\ \ \frac{p_{B2}^{UY} - p_{B2}^{TY} + (2\alpha+1)b^{T}}{b^{U}+b^{T}}b^{U} - p_{B2}^{UY} \geq 0$$

The first constraint is T's reaction function while the second constraint $\frac{p_{B2}^{UY} - p_{B2}^{TY} + (2\alpha+1)b^{T}}{b^{U}+b^{T}}b^{U} -$

$p_{B2}^{UY} \geq 0$ will be binding as being discussed before. The solution can be found by solving the two binding constraints simultaneously. Plugging T's reaction function (the first constraint) into the second binding constraint, we have:

$$\left[p_{B2}^{UY} - \frac{(\alpha+1)b^T + c^T - \alpha b^U + p_{B2}^{UY}}{2} + (2\alpha+1)b^T\right] b^U - p_{B2}^{UY}(b^U + b^T) = 0$$

Thus, the pricing equations for U and T are:

$$p_{B2}^{UY} = \frac{b^U[\alpha b^U + (3\alpha+1)b^T - c^T]}{b^U + 2b^T}$$

$$p_{B2}^{TY} = \frac{b^T[(\alpha+1)b^U + (\alpha+1)b^T + c^T]}{b^U + 2b^T}$$

As a result, we have:

$$p_{B2}^{UY} - p_{B2}^{TY} = \frac{b^U[\alpha b^U + (3\alpha+1)b^T - c^T]}{b^U + 2b^T} - \frac{b^T[(\alpha+1)b^U + (\alpha+1)b^T + c^T]}{b^U + 2b^T} = \frac{\alpha(b^U)^2 - (\alpha+1)(b^T)^2 + 2\alpha b^U b^T - c^T(b^U + b^T)}{b^U + 2b^T}$$

$$\frac{p_{B2}^{UY} - p_{B2}^{TY} + (2\alpha+1)b^T}{b^U + b^T} = \frac{\alpha\left[(b^U)^2 + (b^T)^2\right] + (4\alpha+1)b^U b^T - c^T(b^U + b^T)}{(b^U + b^T)(b^U + 2b^T)}$$

$$p_{B2}^{UY} - c^U = \frac{b^U[\alpha b^U + (3\alpha+1)b^T - c^T]}{b^U + 2b^T} - c^U = \frac{\alpha(b^U)^2 + (3\alpha+1)b^U b^T - c^T b^U - c^U(b^U + 2b^T)}{b^U + 2b^T}$$

$$p_{B2}^{TY} - c^T = \frac{b^T[(\alpha+1)b^U + (\alpha+1)b^T + c^T]}{b^U + 2b^T} - c^T = \frac{b^T[(\alpha+1)b^U + (\alpha+1)b^T + c^T] - c^T(b^U + 2b^T)}{b^U + 2b^T}$$

Plugging these equations back into the profit functions, we have:

$$\pi_{B2}^{UY} = \left(\frac{\alpha(b^U)^2 + (3\alpha+1)b^U b^T - c^T b^U - c^U(b^U + 2b^T)}{b^U + 2b^T}\right)\left(\alpha + 1 - \frac{\alpha\left[(b^U)^2 + (b^T)^2\right] + (4\alpha+1)b^U b^T - c^T(b^U + b^T)}{(b^U + b^T)(b^U + 2b^T)}\right) N^U$$

$$\pi_{B2}^{TY} = \left(\frac{b^T[(\alpha+1)b^U + (\alpha+1)b^T + c^T] - c^T(b^U + 2b^T)}{b^U + 2b^T}\right)\left(\frac{\alpha\left[(b^U)^2 + (b^T)^2\right] + (4\alpha+1)b^U b^T - c^T(b^U + b^T)}{(b^U + b^T)(b^U + 2b^T)} - \alpha\right) N^U - K_B^T$$

Thus, we have:

$$\pi_{B2}^{UY} = \frac{\left[\alpha(b^U)^2 + (3\alpha+1)b^U b^T - (c^T + c^U)b^U - 2c^U b^T\right]\left[(b^U)^2 + (-\alpha+1)(b^T)^2 + (-\alpha+2)b^U b^T + c^T(b^U + b^T)\right]}{(b^U + b^T)(b^U + 2b^T)^2}$$

$$\pi_{B2}^{TY} = \frac{\left[(\alpha+1)(b^T)^2 + (\alpha+1)b^U b^T - c^T b^U - c^T b^T\right]^2}{(b^U + b^T)(b^U + 2b^T)^2} - K_B^T$$

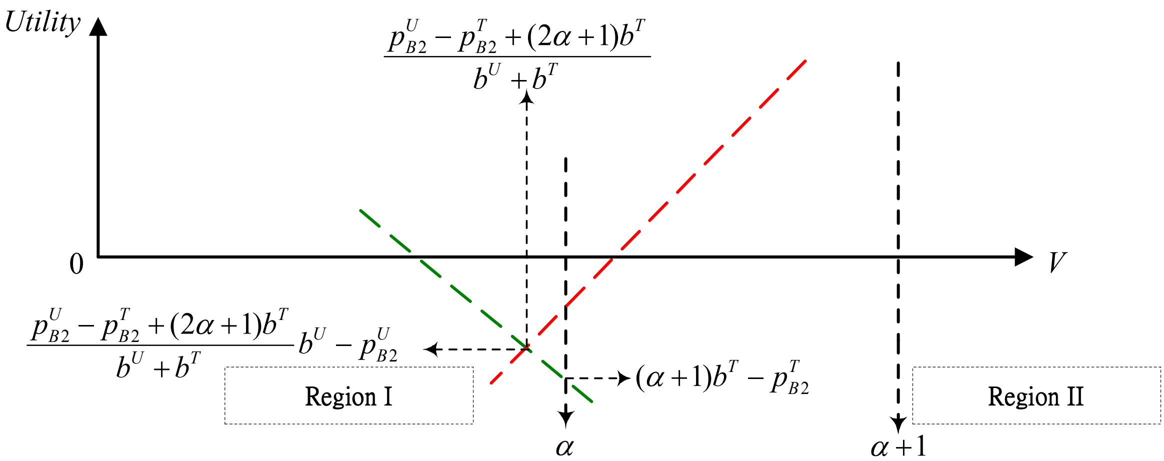
A-03 Why $x \in [\alpha, \alpha+1]$ and $y \geq 0$ Won't Bind Simultaneously

If both constraints bind simultaneously, then under the nonbinding duopoly prices p_{B2}^{U} and p_{B2}^{T}, the intersection of $u = vb^{U} - p^{U}$ and $u = (2\alpha + 1 - v)b^{T} - p^{T}$ must be located either at region I or at region II in Figure A1. If the intersection is located at Region I, then T's price is too high since $(\alpha+1)b^{T} - p_{B2}^{T}$ is negative. Note that since $b^{T} > c^{T}$, now, we have $p_{B2}^{T} > (\alpha+1)b^{T} > c^{T}$. However, since $\frac{p_{B2}^{U} - p_{B2}^{T} + (2\alpha+1)b^{T}}{b^{U}+b^{T}} < \alpha$, T's demand $\frac{p_{B2}^{U} - p_{B2}^{T} + (2\alpha+1)b^{T}}{b^{U}+b^{T}} - \alpha$ will be negative. Let us consider T's profit function:

$$\pi_{B2}^{T} = max_{p_{B2}^{T}} (p_{B2}^{T} - c^{T}) \left(\frac{p_{B2}^{U} - p_{B2}^{T} + (2\alpha+1)b^{T}}{b^{U}+b^{T}} - \alpha \right) N^{U} - K_{B}^{T}$$

Now, we have $(p_{B2}^{T} - c^{T}) \left(\frac{p_{B2}^{U} - p_{B2}^{T} + (2\alpha+1)b^{T}}{b^{U}+b^{T}} - \alpha \right) < 0$. Thus, if p_{B2}^{T} is reduced but $p_{B2}^{T} - c^{T} > 0$, π_{B2}^{T} will go up since $p_{B2}^{T} - c^{T} > 0$ but $p_{B2}^{T} - c^{T}$ decreases, and $\frac{p_{B2}^{U} - p_{B2}^{T} + (2\alpha+1)b^{T}}{b^{U}+b^{T}} - \alpha < 0$ but $\left| \frac{p_{B2}^{U} - p_{B2}^{T} + (2\alpha+1)b^{T}}{b^{U}+b^{T}} - \alpha \right|$ decreases. This shows that mathematically, the nonbinding duopoly solution cannot happen in Region I. By the similar argument, the unconstraint duopoly solution cannot happen in Region II. Thus, the two constraints $x \in [\alpha, \alpha+1]$ and $y \geq 0$ will not be violated simultaneously.

Figure A1 The Utility and the Demand with Both Constraints Bind



A-04 Proof for Proposition 3.1.3

For simplicity, let us consider the case that when the two firms cooperate, the market is not fully occupied. This requires that $\frac{p_O^U}{b^U} = \frac{(\alpha+1)b^U + c^T}{2b^U} \in (\alpha, \alpha+1)$, i.e., $\frac{c^T}{b^U} \in (\alpha-1, \alpha+1)$. By Lemma 2.2.1, there exists a unique pure strategy Nash equilibrium to the first stage non-cooperative game. By Proposition 3.1.2, we only have to consider the case $(Enter, Enter)$. Let us express b^T and c^U as $b^T = b^U - \delta_1$ and $c^U = c^T + \delta_2$, and have $\delta_1 = 0$ and $\delta_2 = 0$ as the starting point for the following cases. First, if the Nash equilibrium is that the two firms do enter in two separate markets, the bargain fails if and only if $\frac{[(\alpha+1)b^U - c^T]^2 N^U}{4b^U} + \frac{[(\alpha+1)b^U - c^T]^2 N^U}{4b^U} - K_B^T \geq \frac{[(\alpha+1)b^U - c^T]^2 N^U}{4b^U}$, i.e, $K_B^T \leq \frac{[(\alpha+1)b^U - c^T]^2 N^U}{4b^U}$ (by Lemma 2.3.1).[34] Now, let us go back to the case with $\delta_1 > 0$ and $\delta_2 > 0$ but $\delta_1 \to 0$ and $\delta_2 \to 0$ (equivalently, $b^U > b^T$ and $c^U > c^T$ but $b^U \to b^T$ and $c^U \to c^T$). Since the profit functions are continuous for any positive brand value, the following conditions hold: (1) $\pi_{B1}^U \to \frac{[(\alpha+1)b^U - c^T]^2 N^U}{4b^U}$ but $\pi_{B1}^U < \frac{[(\alpha+1)b^U - c^T]^2 N^U}{4b^U}$ (2) $\pi_{B1}^T \to \frac{[(\alpha+1)b^U - c^T]^2 N^U}{4b^U} - K_B^T$ but $\pi_{B1}^T < \frac{[(\alpha+1)b^U - c^T]^2 N^U}{4b^U} - K_B^T$. From the continuity of the profit functions, $\exists K_B^T \in [0, \frac{[(\alpha+1)b^U - c^T]^2 N^U}{4b^U})$ such that $\pi_N^U + \pi_N^T \geq \pi_O^I$ (so the bargain fails).

Second, if the Nash equilibrium is that the two firms coexist but only U is the monopolist, then T enters but does not really fight with U since T only captures the residual demand. Under $\delta_1 = 0$ and $\delta_2 = 0$, $\pi_{B1}^U = \frac{[(\alpha+1)b^U - c^T]^2 N^U}{4b^U} = \pi_O^I$ and $\pi_{B1}^{TN} = \frac{[(\alpha+1)b^U - c^T]^2 N^U}{4b^U} - K_B^T$.[35] So $\pi_{B1}^U + \pi_{B1}^{TN} \geq \pi_O^I$ holds if and only if $K_B^T \leq \frac{[(\alpha+1)b^U - c^T]^2 N^U}{4b^U}$. From the continuity of the profit functions, when $\delta_1 > 0$ and $\delta_2 > 0$ but $\delta_1 \to 0$ and $\delta_2 \to 0$, we have $\pi_{B1}^U \to \frac{[(\alpha+1)b^U - c^T]^2 N^U}{4b^U}$ and $\pi_{B1}^{TN} \to \frac{[(\alpha+1)b^U - c^T]^2 N^U}{4b^U} - K_B^T$, and $\exists K_B^{T0} \in (\frac{[(\alpha+1)b^U - c^T]^2 N^U}{4b^U} - \epsilon, \frac{[(\alpha+1)b^U - c^T]^2 N^U}{4b^U} + \epsilon)$ with

[34] Note that $\delta_1 = 0$ and $\delta_2 = 0$ means $b^T = b^U$ and $c^U = c^T$. The profit functions π_{B1}^U, π_{B1}^T, and π_O^I are from (3), (6), and (34).
[35] The profit function π_{B1}^{TN} is from (12).

$\epsilon \to 0^+$ such that $\pi_{B1}^U + \pi_{B1}^{TN} \geq \pi_O^I$ holds if and only if $K_B^T \leq K_B^{T0}$.

Third, if the Nash equilibrium is that the two firms engage in a nonbinding duopolistic competition, then, under $\delta_1 = 0$ and $\delta_2 = 0$, $\pi_{B2}^U = \frac{9b^U N^U}{16}$, $\pi_{B2}^T = \frac{25b^U N^U}{32} - K_B^T$, and $\pi_O^I = \frac{[(\alpha+1)b^U - c^T]^2 N^U}{4b^U}$.[36] So, $\pi_{B2}^U + \pi_{B2}^T \geq \pi_O^I$ holds if and only if $K_B^T \leq \frac{\{[43-8(\alpha+1)^2](b^U)^2 - 8(c^T)^2 + 16(\alpha+1)c^T b^U\}N^U}{32b^U} = K_B^{T1}$. We need to verify that $K_B^{T1} > 0$ conforms with the nonbinding duopoly case, i.e., $x \in (\alpha, \alpha+1)$ and $y \geq 0$, where (x, y) is the intersection of $u = vb^U - p_{B2}^U$ and $u = (2\alpha + 1 - v)b^T - P_{B2}^T$. Under $b^T = b^U$ and $c^U = c^T$, from (18) and (19), we have $p_{B2}^U = \frac{3}{2}b^U + c^T$ and $p_{B2}^T = \frac{5}{4}b^U + c^T$. Plugging these into $x = \frac{[p_{B2}^U - p_{B2}^T + (2\alpha+1)b^T]}{b^U + b^T}$ and $y = \frac{[p_{B2}^U - p_{B2}^T + (2\alpha+1)b^T]}{b^U + b^T} b^U - p_{B2}^U$, we have $x = \alpha + \frac{5}{8}$ and $y = \left(\alpha - \frac{7}{8}\right) b^U - c^T$. Obviously, $x = \alpha + \frac{5}{8} \in (\alpha, \alpha+1)$ always holds. The condition $y \geq 0$ holds if and only if $\alpha \geq \frac{c^T}{b^U} + \frac{7}{8}$. Taking $c^T = \frac{b^U}{8}$ as an example (so, $\alpha = \frac{c^T}{b^U} + \frac{7}{8} \geq 1$ in this case), now $y = 0$ if and only if $\alpha = 1$. Let us consider $c^T = \frac{b^U}{8}$ and $\alpha = 1$. Now, plugging c^T and α back into K_B^{T1}, we have $K_B^{T1} = \frac{119b^U N^U}{256} > 0$. So, $\pi_{B2}^U = \frac{9b^U N^U}{16} > 0$ and $\pi_{B2}^T = \frac{25b^U N^U}{32} - K_B^T = \frac{81b^U N^U}{256} > 0$. As a result, the nonbinding duopoly holds. Furthermore, under the cooperation, the market will not be fully occupied since $\frac{c^T}{b^U} \in (\alpha - 1, \alpha + 1)$ is satisfied. Finally, from the continuity of the profit functions, when $\delta_1 \to 0^+$ and $\delta_2 \to 0^+$, taking $c^T = \frac{b^U}{8}$ and $\alpha = 1$ for example, we have $\pi_{B2}^U \to \frac{9b^U N^U}{16}$ and $\pi_{B2}^T \to \frac{81b^U N^U}{256}$, and $\exists K_B^{T1} \in (\frac{119b^U N^U}{256} - \epsilon, \frac{119b^U N^U}{256} + \epsilon)$ with $\epsilon \to 0^+$ such that $\pi_{B2}^U + \pi_{B2}^T \geq \pi_O^I$ holds if and only if $K_B^T \leq K_B^{T1}$.

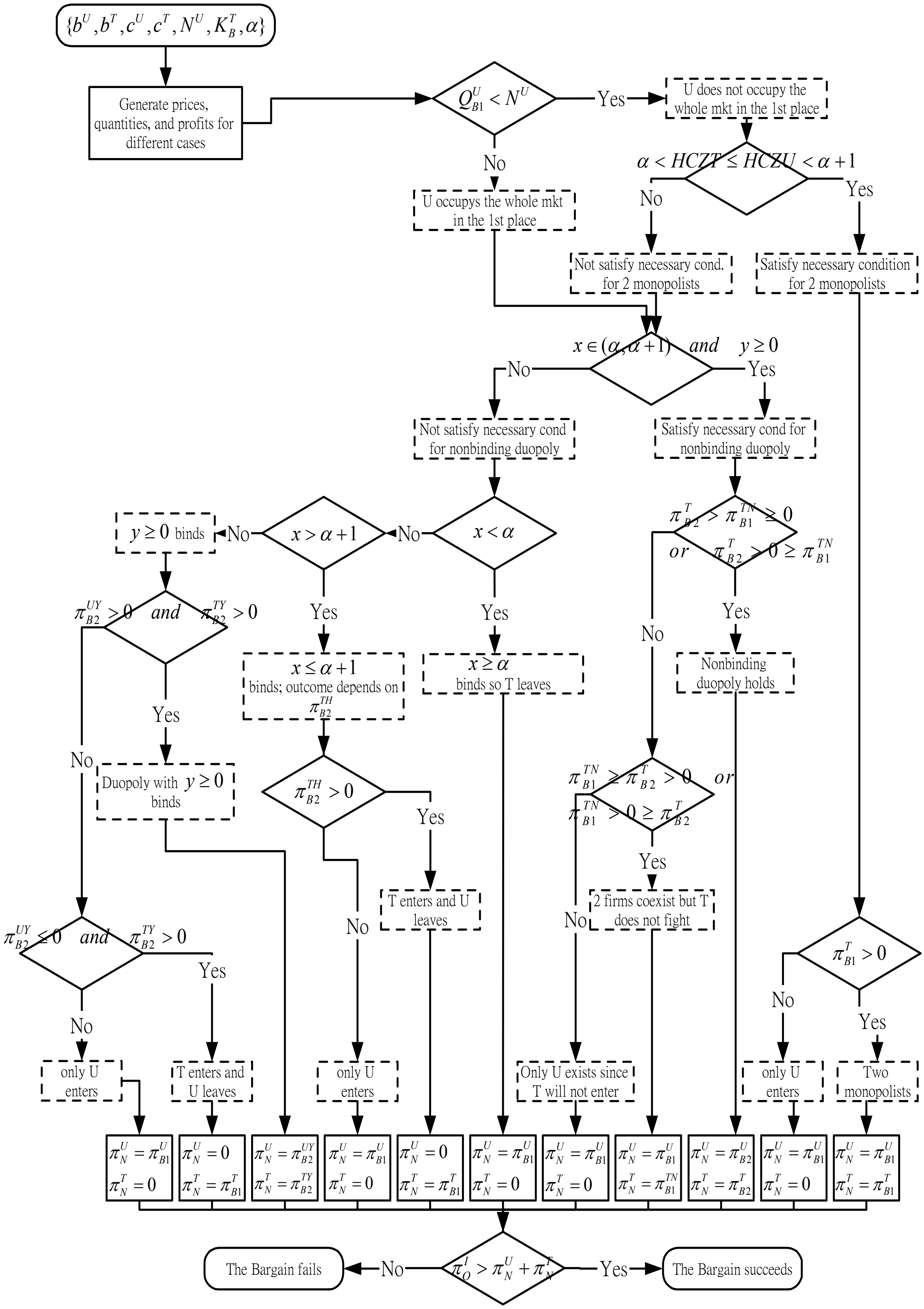
Fourth, if the Nash equilibrium is that the two firms engage in a duopolistic competition with $y \geq 0$ binds, under $\delta_1 = 0$ and $\delta_2 = 0$, $\pi_{B2}^{UY} = \frac{[(4\alpha+1)(b^U)^2 - 4c^T b^U][(-2\alpha+4)(b^U)^2 + 2c^T b^U]N^U}{18(b^U)^3}$, $\pi_{B2}^{TY} =$

[36] The profit functions π_{B2}^U and π_{B2}^T are from (21) and (22).

$\frac{\left[(2\alpha+2)\left(b^U\right)^2-2c^Tb^U\right]^2N^U}{18(b^U)^3} - K_B^T$, and $\pi_O^I = \frac{[(\alpha+1)b^U-c^T]^2N^U}{4b^U}$, the bargain fails if and only if $\pi_{B2}^{UY} + \pi_{B2}^{TY} \geq \pi_O^I$.[37] This is equivalent to $K_B^T \leq \frac{\left[(-17\alpha^2+26\alpha+7)\left(b^U\right)^2+(34\alpha-26)c^Tb^U-17\left(c^T\right)^2\right]N^U}{36b^U} = K_B^{T2}$. From (29) and (31), $p_{B2}^{UY} = \frac{(4\alpha+1)b^U-c^T}{3}$ and $p_{B2}^{TY} = \frac{(2\alpha+2)b^U+c^T}{3}$. Plugging these into $x = \frac{[p_{B2}^{UY}-p_{B2}^{TY}+(2\alpha+1)b^T]}{b^U+b^T}$ and $y = \frac{[p_{B2}^{UY}-p_{B2}^{TY}+(2\alpha+1)b^T]}{b^U+b^T}b^U - p_{B2}^U$, we have $x = \frac{(8\alpha+2)b^U-2c^T}{6b^U}$ and $y = 0$. The condition $x = \frac{(8\alpha+2)b^U-2c^T}{6b^U} \in (\alpha, \alpha+1)$ is equivalent to $\frac{c^T}{b^U} \in (\alpha-2, \alpha+1)$. Taking $\frac{c^T}{b^U} = \alpha < 1$ for example and plugging $c^T = \alpha b^U$ into K_B^{T2}, π_{B2}^{UY}, and π_{B2}^{TY}, we have $K_B^{T2} = \frac{7b^UN^U}{36}$, $\pi_{B2}^{UY} = \frac{2b^UN^U}{9}$, and $\pi_{B2}^{UY} = \frac{b^UN^U}{36}$. The duopoly with $y \geq 0$ binding holds. Furthermore, under the cooperation, the market will not be fully occupied since $\frac{c^T}{b^U} \in (\alpha-1, \alpha+1)$. Finally, from the continuity of the profit functions, when $\delta_1 > 0$ and $\delta_2 > 0$ but $\delta_1 \to 0$ and $\delta_2 \to 0$, taking $\frac{c^T}{b^U} = \alpha < 1$ for example, we have $\pi_{B2}^{UY} \to \frac{2b^UN^U}{9}$, and $\pi_{B2}^{TY} \to \frac{b^UN^U}{36}$, and $\exists K_B^{T2} \in (\frac{7b^UN^U}{36} - \epsilon, \frac{7b^UN^U}{36} + \epsilon)$ with $\epsilon \to 0^+$ such that $\pi_{B2}^{UY} + \pi_{B2}^{TY} \geq \pi_O^I$ holds if and only if $K_B^T \leq K_B^{T2}$. By Lemma 2.2.1, we do not have to consider the binding duopoly cases with $x \geq \alpha$ or $x \leq \alpha + 1$ since none of them will be the final outcome. **Q.E.D.**

[37] The profit functions π_{B2}^{UY} and π_{B2}^{TY} are from (30) and (32).

A-05 The Flow Chart of the Program



A-06 Branding Statuses of Taiwanese Firms in 3-C Industries

Laptop Manufacturers

Number of firms = 15	Share of firm's total sale	Share of ODM (OEM) output	Taiwan	China/Developing countries	Developed countries
ACER	>39%	0%	▲	▲	▲
Arima Computer	86%	100%			
ASUS	32%	70%	▲	▲	▲
BenQ			▲	▲	▲
CLEVO	95%		▲		
Compal Electronics[38]	70%(2006:Q1-2)	>95%	▲		
EliteGroup	30%	>50%	▲		
FIC Global, Inc.[39]		75%	▲	▲	
GIGABYTE	<33%	0%	▲	▲	▲
Inventec	70%	100%			
Micro-Star International	12%	0%	▲	▲	
MiTAC Technology	95%	100%			
Quanta Computer	87%	100%			
Twinhead	87%		▲	▲	▲
Wistron Corporation	82%	100%			
			10	7	5

Desktop Manufacturers

Number of firms = 8	Share of firm's total sale	Share of ODM (OEM) output	Taiwan	China/Developing countries	Developed countries
ACER	<61%	0%	▲	▲	▲
ASUS			▲	▲	▲
First International Computer[40]			▲		
Foxconn		100%			
GIGABYTE	19.62%	88.24%	▲		
MiTAC International[41]	30%	>50%	▲	▲	
Tatung	<45%	100%			
Wistron Corporation	4%	100%			
			5	3	2

▲= Branding

[38] In 2007, Quanta Computer and Compal Electronics are the world's largest and second largest OEM/ODM laptop manufacturers, respectively. In 2007, Quanta Computer produces 30 million laptops while Compal Electronics produces 23 million ones. They account for more than 50% of world's laptop computer output.

[39] FIC Global has two brands: 1) Leo (now operated by its subsidiary company); and 2) Everex. However, Everex was originally a U.S. branding firm which was bought by FIC Global. Here, this paper only counts Leo as the brand name of FIC Global. In 2008, FIC Global will enter the U.S. market again and market one of its laptop products under the brand Everex.

[40] This is one of the subsidiary companies of FIC Global.

[41] This is the parent company of MiTAC Technology.

A-06 Branding Statuses of Taiwanese Firms in 3-C Industries (Continued)

Monitors (for Desktop; TV; Other purposes)					
Number of firms = 14	Share of firm's total sale	Share of ODM (OEM) output	Taiwan	China/Developing countries	Developed countries
AG Neovo	96%	0%	▲	▲	▲
AUO	99%	100%			
Chunghwa Picture Tubes	99%	100%			
Compal Electronics	8%	100%			
Foxlink image Tech.					
Hanton	54%		▲	▲	▲
Innolux	83%	100%			
JEAN	67%		▲	▲	
Liteon	49%	100%			
MAG	88%	35%(2001)	▲	▲	▲
Microtek	18%	>0%	▲	▲	▲
Qisda	66%	100%			
SlimAge	69%	100%			
Yuan High-Tech					
			5	5	4

Scanner and Multi-function Printer (MFP) Manufacturers					
Number of firms = 11	Share of firm's total sale	Share of ODM (OEM) output	Taiwan	China/Developing countries	Developed countries
Avision	60%(2006)	>75%	▲	▲	
Foxlink image Tech.					
Genius		41%	▲	▲	
Microtek	78%		▲	▲	▲
Mustek	15%	33%	▲	▲	▲
Plustek[42]			▲	▲	▲
Primax[43]		60%(2001)	▲	▲	▲
Qisda		100%			
Silitek		100%			
Teco Image Systems	87.28%	100%			
UMAX		>0%	▲	▲	▲
			7	5	5

▲= Branding

[42] Plustek is not a listed company. It had been an OEM/ODM firm before.

[43] Besides OEM/ODM businesses, Primax has bought Visioneer, a U.S. branding company, and sell its products under Visioneer and Primax.

A-06 Branding Statuses of Taiwanese Firms in 3-C Industries (Continued)

Cell Phone Manufacturers					
Number of firms = 12	Share of firm's total sale	Share of ODM (OEM) output	Taiwan	China/Developing countries	Developed countries
Arima Communications	90%	100%			
ASUS	<10%		▲	▲	▲
BenQ	4%		▲	▲	
Compal Electronics	22%(2006:Q1-2)	100%			
DBTEL	7%		▲		
Foxconn		100%			
GIGABYTE Communications	100%		▲	▲	
HTC	95%	30%	▲	▲	▲
Inventec (OKWAP)	98%	85%	▲	▲	
Qisda	<2%	100%			
Quanta Computer	<12%	100%			
Wistron NeWeb Corp	28%	>50%	▲	▲	
			7	6	2

Consumer Electronics (Audio System, Digital Camera, Household Appliances, GPS, etc.)					
Number of firms = 32	Share of firm's total sale	Share of ODM (OEM) output	Taiwan	China/Developing countries	Developed countries
Ability Enterprise (DSC)	100%				
Acer (GPS)		0%	▲	▲	▲
Aiptek (DV, DSC)	96%	0%	▲	▲	▲
Altek (DSC)	100%	100%			
Asia Optical (DSC)	78%	100%			
BenQ (DSC)			▲	▲	▲
BTC (DSC)	<40%		▲		
Chicony (DV, DSC)		100%			
DXG Technology (DV, DSC)	97%	0%	▲	▲	▲
Eastern Asia Tech. (Audio)	100%	100%			
E-Lead Electronic (Car Elec.)	92%		▲		
Foxlink image Tech. (DSC)					
Garmin (GPS)	100%	0%	▲	▲	▲
Genius (DSC)	30%	41%	▲	▲	
GlobalSat (GPS)	100%	>0%	▲	▲	▲
Hanpin Electron (Audio)	99%	100%			
Holux (GPS)	100%	>0%	▲	▲	▲
Inventec (GPS)		100%			
Jazz Speakers (Audio)	98%		▲	▲	
Kinpo Electroincs (GPS)		100%			
Leadtek (GPS)	25%~30%	>0%	▲	▲	▲
Meiloon Industrial (Audio)	100%	100%			
MiTAC/Mio (GPS)	40%	50%	▲	▲	▲
Mustek (DSC)	11%		▲	▲	▲
Phonic (Audio)	100%	80%	▲	▲	▲
Premier Image Te.(DV, DSC)	100%	>90%	▲	▲	▲
Quanta Computer (GPS)	<12%	100%			
Royaltek (GPS)	100%	>0%	▲	▲	▲
Sampo (Home App.)	98%	45%(2003)	▲	▲	
Tekom Technologies (DSC)	99%	100%			
Wistron Corporation (GPS)	<12%	100%			
Ya Horng Electronic (Audio)	93%	100%			
			18	16	13

▲= Branding

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