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Abstract

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Abstract

This paper examines how the parallel trade influences the pharmaceutical innovation and welfare. We consider the case where one monopolist in the home potentially sells in the both domestic and foreign markets with different price elasticities of demand. As relevant in the pharmaceutical context, the price of a good sold in the foreign country is determined by the negotiation between the firm and the foreign government. When the parallel trade is allowed, this negotiated foreign price also becomes the domestic price and thus the firm cannot set different price in each market. This paper shows that the parallel trade may enhance pharmaceutical innovation, when the bargaining power of the foreign government is strong and the price elsticity of demand in the foreign market is small.

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1 Introduction

Recently, many economists argue that high income countries should prohibit the parallel imports of drugs from low income countries. A ban on the parallel imports enables the pharmaceutical campany to set different prices in different markets according to their price elasticities of demand ("demand elasticities based price differentials"). Since demand elasticities are inversely related to income, the profit maximizing pharmaceutical campany sets lower (higher) drug prices at lower (higher) income countries. This means that the differential pricing due to the ban on the parallel imports improves the access to the medicine in low income countries. Moreover, it provides a greater incentive for a product development to the pharmaceutical campany, since it can allow them to capture closer to full social surplus of their product. Therefore, differential pricing due to the ban on parallel trade is considered to be promising ways to improve the access to medicine in developping country, and to preserve incentives for R&D.

However, besides the "demand elasticities based price differrentials", there are many other factors which explains the observed cross national drug price differentials. In particular, the governmental price regulation for pharmaceutical products must be crucial. In addition, it is known that the negotiation between pharmaceutical campany and government contributes much to the way and the extent of the governmental price regulation.

Focusing upon the role of the negotiation in the drug price determination, Pecorino (2002) reexamines the impact of the parallel trade upon the pharmaceutical campany's profits and R&D incentives. In his model, one monopolist in the home sells in the both domestic and foreign markets with identical demand elasticities. In the domestic market, the firm can freely set its price, while, in the foreign market, the price is determined by the Nash bargaining game between the firm and the foreign government. In the No reimport regime (NR regime), since parallel trade is not allowed, the perfect market segmentation is possible. Thus the firm charges its profit maximizing price in the domestic market, while the negotiated foreign price becomes lower than in the domestic market. Therefore, this price differentials in the NR regime occurs purely due to the negotiation based factor ("negotiation based price differentials"). In the Reimport regime (R regime), since the parellel trade is allowed, the law of one price holds. Thus the negotiated foreign price also becomes the domestic price as well ("uniform pricing effect"). In this regime, the negotiation results influesnces not only the profits from sales in the foreign market but also the profits from sales in the domestic markets. Thus firm has incetive to bargain harder in the R regime than in the NR regime ("strengthened negotiation effect").

These results imply that the allowance of the parallel trade may provide the following two competing impacts upon the firm's profits and incentives to invest in R&D. First, the "uniform pricing effect" due to the parallel trade negatively influences the firm's profits, since it lowers the domestic price. Second, the "strengthened negotiation effect" positively influences the firm's profits, since it increases the uniform price in the both domestic and foreign markets. Then Pecorino (2002) shows that the "strengthened negotiation effect" always dominates the "uniform pricing effect". Thus parallel trade provides positive impacts upon the pharmaceutical company's profits and incentives to invest in R&D.

These existing studies imply that if the differential pricing is purely demand elasticities based, the parallel trade lowers pharmaceutical innovation. However, if the differential pricing is purely negotiation based, the parallel trade promotes pharmaceutical innovation. Therefore, in order to extend these existing studies, this paper constructs the model which enables us to analyze the case where the price differentials occur due to both demand elasticities and negotiation based factors. Then we analyze more extensively under what economic environments the parallel trade are more likely to lead higher or lower pharmaceutical innovation. This paper extends the model by Pecorino (2002) in the following two ways. First, we consider the case where each domestic and foreign market has different price elasticities of demand, which enables us to analyze the case where the price differentials occurs due to both demand elasticities and the negotiation based factors. Second, we explicitly formulates the firm's decisions of R&D investment, which is not explicitly analyzed in Pecorino (2002). Based upon these two extentions, this paper shows that parallel trade may enhance pharmaceutical innovation, when the bargaining power of foreign government is strong and the price elsticity of demand in the foreign market is small.

The strucuture of the paper is as follows. Section 2 presents the basic set up. Section 3 examines the case, when the parallel imports are not allowed (NR regime). Section 4 examines the case , when the parallel imports are allowed (R regime). Section 5 examines the impact of parallel trade upon R&D investment by comparing the results under the NR regiem and the R regime. Finally, section 6 concludes.

2 Basic Setup

We use a simple partial equilibrium model of trade which consists of two countries: home (H) and Foreign (F). A firm in the home country produces a good of quality $s > 0$ which can be thought of as a pharmaceutical product and sells in the both domestic and foreign markets. We use a model of vertical product differentiation to represent consumer preferences in each market. Consumers differ in their tastes for the product quality, but they rank quality in the same way. When a consumer of type t in the market $i = H, F$ buys a product of quality s at a price p^i, his or her utility is given by $u^i = ts - p^i$. If a consumer does not buy, his or her outside option is normalized zero. The type of consumer t is uniformly distributed between 0 and T^i with unit density. For clarity of the analysis, we only consider the case $T^F \leq T^H$ and assumes that $T^H = T$ and $T^F = \phi T \quad 0 \leq \phi \leq 1$, where ϕ measures the size of the maximum willingness to pay in the foreign market relative to the domestic market. It also measures the value of the price elasticities of demand in the foreign market relative to the domestic market. Thus the lower value of ϕ implies the higher value of the price elasticities of demand in the foreign market relative to the domestic market.[1]

Firm conducts R&D and sets the quality of its product according to a cost function $C(s)$, which satisfies $C'(s) > 0$ and $C''(s) > 0$. Then it manufactures and delivers its product in the both domestic and foreign markets. Once a product has been discovered, its marginal cost of production is not affected by the level of quality. Thus we normalize the marginal cost of production to zero. If the home government provides no re-import regime (NR regime), re-imports of the good back into the home country are not allowed. Thus firm can set different price in each market because perfect market segmentation is possible in the NR regime. However, if the home government provides re-import regime (R regime), re-imports of the good back into the home country are allowed. Thus firm has to set uniform price in the both domestic and foreign market.

Therefore, the time procedure of the decision making is summarized as follows. First, the home government declares a parallel trade regime. Then firm decides on the quality levels with which it will endow its product. Finally, a firm manufactures and delivers the product in each market and sets the prices. In the following subsections, we examine the quality and price determination process in the both NR and R regimes.

[1]The price elasticities of demand in the domestic market ϵ_H and in the foreign market ϵ_F are expressed as follows: $\epsilon_H = \frac{p}{sT-p}$ and $\epsilon_F = \frac{p}{s\phi T-p}$. Therefore, the lower value of ϕ implies the higher value of the price elasticities of demand in the foreign market relative to the domestic market.

3 NR Regime

We first consider the price determination process under the assumption that costs of quality development have already been sunk. Since perfect market segmentation is possible in the NR regime, firm can set different prices in each market. In the domestic market, since the firm has patent protection on this product, it can act as a monopolist . Since t is uniformly distributed between 0 to T^H, the demand in the home is $X^H(p^H) = \frac{sT-p^H}{s}$. Thus the profits on domestic sales are given by

$$\Pi^H(p^H) = \frac{sT - p^H}{s} p^H. \tag{1}$$

By maximizing equation (1), with p^H, we obtain

$$p_{NR}^H(s) = \frac{sT}{2}, \tag{2}$$

$$\Pi_{NR}^H(s) = \frac{(sT)^2}{4s}, \tag{3}$$

where $p_{NR}^H(s)$ is the price and $\Pi_{NR}^H(s)$ are the profits in the domestic market in the NR regime. In order to stress that these values depend upon the level of product quality s, we denote them as a function of s.

The demand and the profits in the foreign market are given by $X^F(p^F) = \frac{s\phi T-p^F}{s}$ and $\Pi^F(p^F) = \frac{s\phi T-p^F}{s}p^F$. If the firm were free to set its price in the foreign market, it would charge monopoly price $\frac{s\phi T}{2}$ and obtains the profits $\frac{(s\phi T)^2}{4s}$. However, this paper assumes that the price in the foreign market is determined by the Nash bargaining game between the firm and the foreign government. This assumption is relevant in the pharmaceutical context.

The foreign government would like to maximize consumer surplus in its country, while the monopolist would like to maximize profits from sales in the foreign market. The consumer surplus in the foreign country is given by $CS^F(p^F) = \frac{(s\phi T-p^F)^2}{2s}$. In the absence of agreement, profits and consumer surplus are both zero. Thus zero is the threat point for both of the domestic firm and the foreign government. Therefore the Nash bargained price in the foreign market in the NR regime p_{NR}^F is found by maximizing

$$[CS^F(p^F)]^\alpha[\Pi^F(p^F)]^{1-\alpha}, \tag{4}$$

with p^F subject to the condition that $X^F(p^F) \geq 0$ and $CS^F(p^F) \geq 0$. Here α reflects the bargaining power of the foreign country. Simple calculation yields

$$p_{NR}^F(s) = \frac{(1-\alpha)s\phi T}{2}, \tag{5}$$

$$\Pi^F_{NR}(s) = \frac{(1-\alpha^2)(s\phi T)^2}{4s}, \tag{6}$$

where $p^F_{NR}(s)$ is the price and $\Pi^F_{NR}(s)$ are the profits in the foreign market in the NR regime. The results here depend very obvious way on α. When $\alpha = 1$, since the foreign government has the all the bargaining power, we must have $p^F_{NR}(s) = 0$ and $\Pi^F_{NR}(s) = 0$, which means that profits for sales in the foreign market is zero. On the other hand, when $\alpha = 0$, since the domestic firm has the all the bargaining power, we have $p^F_{NR}(s) = \frac{s\phi T}{2}$ and $\Pi^F_{NR}(s) = \frac{(s\phi T)^2}{4s}$ which means that the domestic firm charges the monopoly price and obtains monopoly profits in the foreign market.

In the NR regime, total profits of the firm, which is given by $\Pi^{Total} = \Pi^H + \Pi^F$, are

$$\begin{aligned} \Pi^{Total}_{NR}(s) &= \Pi^H_{NR}(s) + \Pi^F_{NR}(s), \\ &= \frac{(sT)^2}{4s}[1 + (1-\alpha^2)\phi^2], \end{aligned} \tag{7}$$

where $\Pi^{Total}_{NR}(s)$ are total profits from sales in the both domestic and foreign markets in the NR regime. Moreover, in the NR regime, consumer surplus of home $CS^H_{NR}(s)$, social surplus of home $SS^H_{NR}(s)$, and consumer surplus of foreign $CS^F_{NR}(s)$ are given by

$$\begin{aligned} CS^H_{NR}(s) &= \frac{(sT - P^H_{NR}(s))^2}{2s}, \\ &= \frac{(sT)^2}{8s}, \end{aligned} \tag{8}$$

$$\begin{aligned} SS^H_{NR}(s) &= \Pi^{Total}_{NR}(s) + CS^H_{NR}(s), \\ &= \frac{(sT)^2}{8s}[3 + 2\phi^2(1-\alpha^2)], \end{aligned} \tag{9}$$

$$\begin{aligned} CS^F_{NR}(s) &= \frac{(s\phi T - P^F_{NR}(s))^2}{2s}, \\ &= \frac{(s\phi T)^2}{8s}(1+\alpha)^2, \end{aligned} \tag{10}$$

where social surplus of home is determined by the total profits of domestic firm $\Pi^{Total}_{NR}(s)$ and consumer surplus of home $CS^H_{NR}(s)$.

Then we consider the quality choice of the firm. Firm will choose its quality level s in order to maximize its profit:

$$\Pi^{Total}_{NR}(s) - C(s). \tag{11}$$

The First Order Condition to this problem implies

$$\begin{aligned} C'(s) &= \Pi_{NR}^{Total'}(s), \\ &= \frac{T^2}{4}[1+(1-\alpha^2)\phi^2] = \frac{\Pi_{NR}^{Total}(s)}{s}. \end{aligned} \tag{12}$$

Let the quality level which solves equation (12) be denoted as s_{NR}, which expresses the level of R&D investment conducted by firm in the NR regime. Therefore, by substituting this s_{NR} into equations (2), (5),(7),(8),(9) and (10), we can obtain the value of prices in the both domestic and foreign markets, consumer surplus and social surplus of home, and consumer surplus of foreign in the NR regime.

4 R Regime

We first consider the price determination process. In the R regime, the negotiated foreign price also becomes the domestic price as well, due to the ability to reimport and no transportaion costs,. Thus the law of one price holds for the good in question: (i.e. $p^H = p^F = p$).

The negotiation between the firm and the foreign government is again formulated as a Nash bargaining process. The foreign government's surplus from the bargaining in the R regime is $CS^F(p)$ and threat point is zero, which is analogous to the NR regime case. However, domestic firm's surplus changes from $\Pi^F(p^F)$ in the NR regime to $\Pi^H(p) + \Pi^F(p) - \Pi_{NR}^H(s)$ in the R regime, where $\Pi^H(p)+\Pi^F(p)$ reflects profits in both the domestic and foreign markets when reimports are allowed and $\Pi_{NR}^H(s)$ reflects the profits only from sales in the domestic market by setting home monopoly price $\frac{sT}{2}$. These changes in the firm's surplus and the threat points are explained as follows. In the NR regime, whether or not a bargaining is reached, profits from home sales are always $\Pi_{NR}^H(s)$. Therefore, firm's surplus from the bargaining is independent of the profits from home sales. However, in the R regime, the firm's profits from domestic market is influenced by the negotiated foreign price. As a result, the term $\Pi^H(p)$ appears in the firm's surplus. In the absence of agreement, the firm can not sell in the foreign market. However, the firm can at least obtain profits $\Pi_{NR}^H(s)$ by setting monopoly price $\frac{sT}{2}$ in the home. Therefore, the threat point of firms in the R regime becomes $\Pi_{NR}^H(s)$. This implies that if the condition

$$\Pi^H(p) + \Pi^F(p) \geq \Pi_{NR}^H(s), \tag{13}$$

does not hold, the firm does not to sell in the foreign market. Taking this constraints into account, we obtain the following lemma.

Lemma 1 *If the price elasticities of demand in the foreign market relative to in the domestic market is sufficiently high to satisfy the condition that* $\phi < \sqrt{2} - 1$, *there exists no incentives for firms to sell in the foreign market in the R regime.*

The proof is shown in Appendix A. When the price elasticities of demand in the foreign market is sufficiently high to satisfy the condition that $\phi < \sqrt{2}-1$, firm would have to set sufficiently low uniform price in the both domestic and foreign markets, if it sold in the foreign market. However, profits obtained form sales in both domestic and foreign market under this low uniform price is smaller than those profits obtained by selling only in the domestic market $\Pi^H_{NR}(s)$. Thus, when $\phi < \sqrt{2} - 1$, the firm sets its price at $\frac{sT}{2}$ and only sells in the domestic market. Therefore, the price in the R regime $p_R(s)$ is given by

$$\begin{aligned} p_R(s) &= \frac{sT}{2} \\ &\equiv p_{R1}(s) \quad if\ \phi < \sqrt{2} - 1. \end{aligned} \tag{14}$$

where $p_{R1}(s)$ denotes the price in the R regime when $\phi < \sqrt{2} - 1$. Since $p_{R1}(s)$ is monopoly price in the home, the condition $p_{R1}(s) = p^H_{NR}(s)$ holds by definition. Thus, when $\phi < \sqrt{2} - 1$, the total profits in the R regime are

$$\begin{aligned} \Pi^{Total}_R(s) &= [\frac{sT - p_{R1}(s)}{s}]p_{R1}(s) \\ &= \frac{(sT)^2}{4s} \\ &\equiv \Pi^{Total}_{R1}(s) \quad if\ \phi < \sqrt{2} - 1, \end{aligned} \tag{15}$$

where $\Pi^{Total}_{R1}(s)$ denotes the profit in the R regime, when $\phi < \sqrt{2} - 1$ and the condition $\Pi^{Total}_{R1}(s) = \Pi^H_{NR}(s)$ holds by definition.

Suppose the condition $\phi \geq \sqrt{2}-1$ holds, the domestic firm and the foreign government reach the agreement and the firm sells in the foreign market. The changes in the domestic firm's surplus and the threat points dicussed above suggest that price concessions by the firm in the R regime are much more costly than in the NR regime, because they affect the domestic market as well as the foreign market. As a result, we should expect the domestic firm to derive a harder bargain in negotiation with the foreign government. While this will tend to help firm profits, the lower price in the domestic mamrket in the NR regime will tend to hurt firm profits. Thus, the overall effect on firm profitability appears to be ambiguous.

Thus, when $\phi \geq \sqrt{2}-1$, Nash bargained uniform price in the R regime p_R is found by maximizing

$$[CS^F(p)]^\alpha[\Pi^H(p)+\Pi^F(p)-\Pi^H_{NR}(s)]^{1-\alpha}, \tag{16}$$

with p subject to the condition that $X^F(p) \geq 0$ and equation (13). Here, equation (13) is rewritten as

$$\tilde{p} \leq p \leq \bar{p}. \tag{17}$$

where

$$\tilde{p} \equiv \frac{sT}{4}[1+\phi-\sqrt{(1+\phi)^2-2}],$$

and

$$\bar{p} \equiv \frac{sT}{4}[1+\phi+\sqrt{(1+\phi)^2-2}].$$

Taking this constraints into accounts, we obtain

$$\begin{aligned} p_R(s) &= \frac{sT}{8}[(1+\alpha)(1+\phi)+4(1-\alpha)\phi-\sqrt{X}] \\ &\equiv p_{R2}(s) \quad if\ \phi \geq \sqrt{2}-1, \end{aligned} \tag{18}$$

where

$$X \equiv (1+\alpha)^2(1+\phi)^2-8[\alpha+(1-\alpha)^2\phi(1-\phi)]$$

and $p_{R2}(s)$ denotes the price in the R regime, when $\phi \geq \sqrt{2}-1$. Thus, when $\phi \geq \sqrt{2}-1$, the total profits $\Pi_R^{total}(s)$ in the R regime are

$$\begin{aligned} \Pi_R^{Total}(s) &= [\frac{sT-p_{R2}(s)}{s}]p_{R2}(s)+[\frac{s\phi T-p_{R2}(s)}{s}]p_{R2}(s) \\ &= \frac{(sT)^2}{4s}Y \\ &\equiv \Pi_{R2}^{Total}(s) \quad if\ \phi \geq \sqrt{2}-1, \end{aligned} \tag{19}$$

where

$$Y \equiv [\frac{(1-\alpha^2)(1+\phi)^2}{4}+2(1-\alpha)^2\phi(1-\phi)+\alpha+\frac{(1-\alpha)(3\phi-1)}{4}\sqrt{X}]$$

and $\Pi_{R2}^{Total}(s)$ denotes the profits in the R regime when $\phi \geq \sqrt{2}-1$. Appendix B explains the deduction of equation (18) more carefully. The results here again depend very obvious way on α. When $\alpha = 1$, since the foreign government has the all the bargaining power, we must have $P_R(s) = \tilde{p}$, that is the lowest price satisfying the participation constraints of the domestic firm. On the other hand, when $\alpha = 0$, since the domestic firm has the all the bargaining power, we have $P_R(s) = \frac{sT}{4}(1+\phi)$ which is the monopoly price that maximizes $\Pi^H(p) + \Pi^F(p)$ given the restriction of uniform pricing.

Moreover, in the R regime, consumer surplus of home $CS_R^H(s)$, social surplus of home $SS_R^H(s)$, and consumer surplus of foreign $CS_R^F(s)$ are given by

$$CS_R^H(s)\begin{cases} = \frac{(sT-P_{R1}(s))^2}{2s} \equiv CS_{R1}^H(s) & \text{if } \phi < \sqrt{2}-1, \\ = \frac{(sT-P_{R2}(s))^2}{2s} \equiv CS_{R2}^H(s) & \text{if } \phi \geq \sqrt{2}-1, \end{cases} \tag{20}$$

where

$$\begin{aligned} CS_{R1}^H(s) &\equiv \frac{(sT)^2}{8s}, \\ CS_{R2}^H(s) &\equiv \frac{(sT)^2}{128s}[7-5\phi+\alpha(3\phi-1)+\sqrt{X}]^2, \end{aligned}$$

and

$$SS_R^H(s)\begin{cases} = \Pi_{R1}^{Total}(s) + CS_{R1}^H(s) \equiv SS_{R1}^H(s) & \text{if } \phi < \sqrt{2}-1, \\ = \Pi_{R2}^{Total}(s) + CS_{R2}^H(s) \equiv SS_{R2}^H(s) & \text{if } \phi \geq \sqrt{2}-1, \end{cases} \tag{21}$$

and

$$CS_R^F(s)\begin{cases} = 0 \equiv CS_{R1}^F(s) & \text{if } \phi < \sqrt{2}-1 \\ = \frac{(s\phi T-P_{R2}(s))^2}{2s} \equiv CS_{R2}^F(s) & \text{if } \phi \geq \sqrt{2}-1 \end{cases} \tag{22}$$

where

$$CS_{R2}^F(s) \equiv \frac{(sT)^2}{128s}[(1+\alpha)(3\phi-1)+\sqrt{X}]^2.$$

Note that when $\phi < \sqrt{2}-1$, since the firm does not sell in the foreign market, the consumer surplus in the foreign market becomes zero.

Then we consider the quality choice of the firm. Firm will choose its quality level s in order to maximize its profit:

$$\Pi_R^{Total}(s) - C(s). \tag{23}$$

The First Order Conditions to this problem imply

$$C'(s) = \Pi_R^{Total\prime}(s), \tag{24}$$

$$\begin{cases} = \frac{T^2}{4} = \frac{\Pi_{R1}^{Total}(s)}{s} & \text{if } \phi < \sqrt{2}-1, \\ = \frac{T^2}{4}Y = \frac{\Pi_{R2}^{Total}(s)}{s} & \text{if } \phi \geq \sqrt{2}-1. \end{cases}$$

Let the quality level which solves equation (24) be denoted as s_{R1} (s_{R2}), which expresses the level of R&D investment conducted by firm in the R regime, when $\phi < \sqrt{2}-1$ ($\phi \geq \sqrt{2}-1$). Therefore, by substituting these s_{R1} and s_{R2} into equations (14), (15),(18),(19),(20),(21) and (22), we can obtain the value of the price, consumer surplus and social surplus of home and consumer surplus of foreign in the R regime.

5 The Impacts of Parallel Trade upon R&D Investment

This section examines how the allowance of the parallel trade influences firm's incentives to investment in R&D by comparing results in the R regime and the NR regime. By comparing the results in equation (12) and (24), we obtain the following proposition

Proposition 1 *1. When the price elasticities of demand in the foreign market is sufficiently high to satisfy the condition that $\phi < \sqrt{2} - 1$, R&D investment in the NR regime is higher than or equal to in the R regime.*

2. When the price elasticities of demand in the foreign market is sufficiently low to satisfy the condition that $\phi \geq \sqrt{2} - 1$,

(a) R&D investment in the NR regime is higher than or equal to in the R regime, if $\Pi_R^{Total}(s) \leq \Pi_{NR}^{Total}(s)$ for $\forall$ s.

(b) R&D investment in the R regime is higher than or equal to in the NR regime, if $\Pi_R^{Total}(s) \geq \Pi_{NR}^{Total}(s)$ for $\forall$ s.

The proof is shown in Appendix C. Proposition 1-1 indicates that the parallel trade leads to lower R&D investment, if the price elasticities of demand in the foreign market is sufficiently high to satisfy the condition that $\phi < \sqrt{2} - 1$. This result is intuitively explained as follows. In the NR regime, as shown in lemma1, firm has no incentive to sell in the foreign market when $\phi < \sqrt{2} - 1$. Thus the frim sells only in the domestic market and obtains profits $\Pi_{R1}^{Total}(s) = \Pi_{NR}^{H}(s)$. However, in the NR regime, since the firm can set different price in different market, there exists an incentive to sell in the both domestic and foreign markets irrespective of the value of ϕ. Thus the firm sets the price $P_{NR}^{H}(s)$ in the home and $P_{NR}^{F}(s)$ in the foreign respectively and obtains profits $\Pi_{NR}^{Total}(s) = \Pi_{NR}^{H}(s) + \Pi_{NR}^{F}(s)$. These results suggest that the firm will lose its oppotunity to obtain profits from foreign market due to the parallel tarade, when $\phi < \sqrt{2} - 1$. Thus the parallel trade lowers the the firm's incentives to invest in R&D.

However, proposition 1-2 inndicates that the parallel trade may not necessarily leads to lower R&D investment, if the price elasticities of demand in the foreign market is sufficiently low to satisfy the condition that $\phi \geq \sqrt{2} - 1$ and the condition $\Pi_R^{Total}(s) \geq \Pi_{NR}^{Total}(s)$ for $\forall$ s holds. As mentioned in the section 4, since the negotiated foreign price affects not only the profits from the foreign market but also the profits from the domestic market, the firm has incentive to derive a harder bargain in the R regime than NR regime. This "strengthened negotiation effect" leads to higher total profits in the R regime than in the NR regime. Therefore, the condition $\Pi_R^{Total}(s) \geq \Pi_{NR}^{Total}(s)\ for\ \forall\ s$ is more likely to hold. However, in the R regime, the law of one price holds due to the ability to reimport. This "uniform pricing effect" leads to lower profits in the R regime than in the NR regime. Therefore, the condition that $\Pi_R^{Total}(s) \geq \Pi_{NR}^{Total}(s)\ for\ \forall\ s$ is less likely to hold. These results suggest that parallel trade lead to higher R&D investment only when the "strengthened negotiation effect" dominates the "uniform pricing effect".

In order to further explore the property of our model, we compare the results under the NR and R regimes for some values of α and ϕ. Firstly, we examine the case when $\alpha = 0$ and 1 and obtain the following results.

Result 1 1. *When alll the bargaining power resides with the domestic firm ($\alpha = 0$), R&D investment in the NR regime is higher than or equal to in the R regime.*

2. *When alll the bargaining power resides with the foreign government ($\alpha = 1$), R&D investment is the same in the NR regime and the R regime.*

The proof is shown in the Appendix *D*. Result 1-1 indicates that the parallel trade leads to lower R&D investment when $\alpha = 0$. When $\alpha = 0$, since all the bargaining power lies with the domestic firm, the firm can freely set the price in the foreign market. In the NR regime, the firm can set different price in different market in both the NR and R regimes. However, in the R regime, firm have to set uniform price in every market. Thus total profits in the R regime is lower than those in the NR regime.[2] This result implies that the parallel trade lowers the firm's profits and incentives to invest in R&D. Note that when $\alpha = 0$, all the bargaining power lies with domestic firms. Thus the impact of the firm's strengthened bargaining power induced by the parallel trade becomes negligible. Therefore, "uniform pricing effect" dominates the "strengthened negotiation effect".

Result 1-2 indicates that the parallel does not provide any impacts upon R&D investment when $\alpha = 1$. When $\alpha = 1$, since all the bargaining power lies with foreign government, the foreign government can freely set the price in the foreign market in both the NR and R regimes. In the NR regime, government maximizes the consumer surplus by setting the foreign price as

[2]The situation examined here when $\alpha = 0$ is the same as the situation examined in the well known models of third degree price discrimination such as Varian (1985) and Malueg and Schwartz (1994).

zero. Thus domestic firm obtain zero profits from sales in the foreign market. This means that the total profits in the NR regime equals to the domestic monopoly profits (i.e. $\Pi_{NR}^{Total}(s) = \Pi_{NR}^{H}(s)$). However, in the R regime, governemnt have to set the price which satisfies the participation constraint of the domestic firm defined in equation (13). Thus the firm sets the foreign price as $\tilde{p}$, which is also becomes the domestic price. From equation (13), when $p = \tilde{p}$, total profits in the R regime equals to the domestic monopoly profits (i.e. $\Pi_{R}^{Total}(s) = \Pi_{NR}^{H}(s)$). These results imply that the parallel trade does not provide any influence upon the firm's profits and incetives to investment in R&D. Note that when $\alpha = 1$, all the bargaining power lies with foreign government. Thus the impact of the firm's strengthened bargaining power induced by the parallel trade becomes significant. Result 1-2 implies that the "strengthened negotiation effect" is large enough to cancell out the "uniform pricing effect".

Secondly, we examine the case when $\phi = \frac{1}{2}$ and 1, respectively and obtain the following results.

Result 2 *1. When the price elasticities of demand in the foreign market satisfies the condition that $\phi = \frac{1}{2}$, R&D investment in the NR regime is higher than or equal to in the R regime.*

2. When the price elasticities of demand in the foreign market satisfies the condition that $\phi = 1$, R&D investment in the R regime is higher than or equal to in the NR regime.

The proof is shown in the Appendix *E*. Result 2-1 and 2-2 indicate that the parallel trade leads to lower R&D investment when $\phi = \frac{1}{2}$, while it leads to higher R&D investment when $\phi = 1$. The higher value of ϕ implies the lower value of the price elasticities of demand in the foreign market. Therefore, the negative impacts of the "uniform pricing effect" becomes smaller as the value of ϕ becomes higher.

When $\phi = \frac{1}{2}$, the price elasticities of demand in the foreign market is high enough. Thus "uniform pricing effect" dominates the "strengthened negotiation effect". When $\phi = 1$, the price elasticities of demand in the foreign market is low enough and equals to those in the domestic market. Thus the "strengthened negotiation effect" dominates the "uniform pricing effect".[3]

Finally we consider the case when $\phi = \frac{3}{4}$ and $\frac{7}{8}$, respectively and obtain the following results.

[3]The situation examined here when $\phi = 1$ is the same as the situation examined in Pecorino(2002).

Result 3 *1. When the price elasticities of demand in the foreign market satisfies the condition that $\phi = \frac{3}{4}$, R&D investment in the R regime is higher (lower) than or equal to in the NR regime, if $\alpha \geq \hat{\alpha}_{\phi=\frac{3}{4}}$ ($\alpha \leq \hat{\alpha}_{\phi=\frac{3}{4}}$). The $\hat{\alpha}_{\phi=\frac{3}{4}}$ is defined as α which satifies the condition that $f_{\phi=\frac{3}{4}}(\alpha) = 0$, where $f_{\phi=\frac{3}{4}}(\alpha) \equiv 5\sqrt{25 + 18\alpha + 25\alpha^2} - (11\alpha + 27)$.*

2. When the price elasticities of demand in the foreign market satisfy the condition that $\phi = \frac{7}{8}$, R&D investment in the R regime is higher (lower) than or equal to in the NR regime, if $\alpha \geq \hat{\alpha}_{\phi=\frac{7}{8}}$ ($\alpha \leq \hat{\alpha}_{\phi=\frac{7}{8}}$). The $\hat{\alpha}_{\phi=\frac{7}{8}}$ is defined as α which satifies the condition that $f_{\phi=\frac{7}{8}}(\alpha) = 0$, where $f_{\phi=\frac{7}{8}}(\alpha) \equiv 13\sqrt{169 + 50\alpha + 169\alpha^2} - (27\alpha + 171)$.

3. The value of $\hat{\alpha}_{\phi=\frac{7}{8}}$ is smaller than the value of $\hat{\alpha}_{\phi=\frac{3}{4}}$.

The proof is shown in the Appendix F. Result 3-1 and 3-2 indicate that given the sufficiently high value of ϕ, the parallel trade leads to higher (lower) R&D investment, when the value of α is higher (lower) than the certain threshold value. Moreover, Result 3-3 provides us an insightful intuition that the range of α where the parallel trade leads to higher R&D investment becomes wider, as the value of ϕ becomes higher. Therefore, Result 3 suggests that the parallel trade is likely to induce higher R&D investment, as the values of both α and ϕ become higher.

The intuition behinds these results are analogous to those in Result 1 and 2. The participation constraints of the firm defined in equation (13) is the key driving force that the firm bargains harder in the R regime than in the NR regime. The influence of this participation constraints become more prominent, when the value of α is high and the bargaining power of the foreign government is strong. Consequently, given the sufficiently high value of ϕ, the "strengthened negotiation effect" is likely to dominate the "uniform pricing effect". In addition, as discussed in Result 2, the higher value of ϕ leads to the smaller impact of "uniform pricing effect". Therefore, the higher value of ϕ lowers the threshold value of α and widens the range of α where the "strengthened negotiation effect" dominates the "uniform pricing effect".

In order to confirm the results discussed above and obtain more intuition, we provide numerical example. For illustrative purposes, we specify the functional form of the cost function of R&D $C(s)$ as

$$C(s) = \frac{1}{\beta} s^{\beta} \quad \beta > 1. \tag{25}$$

Following Valletti (2005), we set the baseline parameterization of the model as follows: $T = 10$, $k = 30$ and $\beta = 3$. Then, given these values, we increases the values of ϕ and α from 0 to 1 in increments of 0.1 respectively.

Table 1 shows the difference in R&D investment $S_R - S_{NR}$ between the two regimes for various sets of the values of ϕ and α. For later analysis, we denote the parameter region of (ϕ, α) which satisfies $\phi \leq 0.4 < \sqrt{2} - 1$ as case 1. The case1 region is expressed as the shaded area in the light gray in Table 1. As shown in Propostion 1, when $\phi \leq 0.4 < \sqrt{2} - 1$, the parallel trade leads to lower R&D investment. In this region, since the price elasticities of demand in the foreign market is too high for the firm to sell in the foreign market in the R regime, the parallel trade reduces the firm's profits and incentives to invest in R&D.

When $\phi \geq 0.5 > \sqrt{2} - 1$, there exists two different regions. One is the region where the parallel trade leads to lower R&D investment. The other is the region where the parallel trade leads to higher R&D investment. We denote the former region as Case 2 and the latter region as Case 3 respectively. The Case 2 (Case 3) region is expressed as the shaded area in the strong gray (as the area without shading) in Table 1. Then we can easily confirm that the case 3 region lies in the area where the values of ϕ and α are higher than those in the case 2. As discussed in Result 1, 2 and 3, when the values both ϕ and α are lower (case 2), the "uniform pricing effect" are likely to dominate the "strengthened negotiation effect". Thus parallel trade leads to lower R&D investment. However, when the values of both ϕ and α are higher (case 3), the "strengthened negotiation effect" are likely to dominate the "uniform pricing effect". Thus parallel trade leads to higher R&D investment.

6 Concluding Remarks

This paper extends the model by Pecorino (2002) in the following two ways. First, we considered the case where each domestic and foreign market had different price elasticities of demand. Second, we explicitly formulated the firm's decisions of R&D investment. Based upon these two extentions, this paper showed that parallel trade might enhance pharmaceutical innovation, when the bargaining power of foreign government was strong and the price elsticity of demand in the foreign market was small.

Appendix A: Proof of Lemma 1

Since $\Pi^H(p) + \Pi^F(p) = [\frac{(1+\phi)sT-2p}{s}]p$, it is the quadratic function of p. Thus $\Pi^H(p) + \Pi^F(p)$ achieves its maximum value of $\frac{(1+\phi)^2(sT)^2}{8s}$ at $p = \frac{(1+\phi)sT}{4}$. Therefore, the relation $\Pi^H(p)+\Pi^F(p) \geq \Pi^H_{NR}(s)$ does not hold, if $\frac{(1+\phi)^2(sT)^2}{8s} <$

$\Pi_{NR}^H(s) = \frac{(sT)^2}{4s}$. Simple calculation shows that this condition can be rewritten as $(1+\phi)^2 \leq 2$ or $\phi < \sqrt{2}-1$.

Appendix B: Deduction of equation (18)

Let us define $V(p) \equiv [CS^F(p)]^\alpha[\Pi^H(p)+\Pi^F(p)-\Pi_{NR}^H(s)]^{1-\alpha}$. By maximizing equation (16) with p subject to $X^F(p) \geq 0$ and equation (17), we obtain the following first and second-order conditions respectively:

$$\Gamma(p) \equiv \alpha\frac{CS^{F\prime}(p)}{CS^F(p)} + (1-\alpha)\frac{\Pi^{Total\prime}(p)}{\Pi^{Total\prime}(p) - \Pi_{NR}^H(s)} = 0 \tag{26}$$

$$\Gamma'(p) = -\alpha\frac{2}{(s\phi T - p)^2}+(1-\alpha)\frac{\Pi^{Total\prime\prime}(p)(\Pi^{Total} - \Pi_{NR}^H(s)) - (\Pi^{Total\prime}(p))^2}{(\Pi^{Total}(p) - \Pi_{NR}^H(s))^2} < 0 \tag{27}$$

where the right hand side of equation (26) is defined as $\Gamma(p)$.

After the tedious calculation, equation (26) is written as

$$4p^2 - [(1+\alpha)(1+\phi)+4(1-\alpha)\phi]sTp + [(1-\alpha)(1+\phi)\phi + \frac{\alpha}{2}](sT)^2 = 0.$$

Thus we obtain the following two candidates of the optimal interior solution.

$$p_1, p_2 = \frac{sT}{8}[(1+\alpha)(1+\phi)+4(1-\alpha)\phi \pm \sqrt{X}].$$

Since $0 \leq \phi \leq 1$ and $(1+\phi)^2 \geq 2$ due to $\phi \geq \sqrt{2}-1$, we can show that

$$\begin{aligned} X &= (1+\alpha)^2(1+\phi)^2 - 8[\alpha + (1-\alpha)^2\phi(1-\phi)] \\ &\geq 2(1+\alpha)^2 - 8[\alpha + (1-\alpha)^2\phi(1-\phi)] \\ &= 2(1-\alpha)^2[1-4\phi(1-\phi)] \geq 0 \end{aligned}$$

Since $CS^F(p)$ is decreasing function of p and $p_2 \leq p_1$, we obtain $CS^F(p_2) \geq CS^F(p_1)$. Moreover, by substituting p_1 and p_2 into $\Pi^H(p)+\Pi^F(p)-\Pi_{NR}^H(s)$, we can show that $\Pi^H(p_2)+\Pi^F(p_2)-\Pi_{NR}^H(s) \geq \Pi^H(p_1)+\Pi^F(p_1)-\Pi_{NR}^H(s)$. Hence we can confirm that the condition $V(p_2) \geq V(p_1)$ holds. Therefore, p_2 becomes the optimal interior solution. Moreover, we can confirm that $p_2 = \frac{sT}{4}(1+\phi)$ when α=0, and $p_2 = \tilde{p}$ when α=1.

Appendix C: Proof of Proposition1

From equation (12) and (24), we can find that the condition $S_{NR} \geq (\leq) S_R$ holds, if and only if $\Pi_{NR}^{Total}(s) \geq (\leq)\Pi_R^{Total}(s)$ *for* $\forall\, s$. When $\phi < \sqrt{2}-1$, from equation (7) and (15), $\Pi_{NR}^{Total}(s) - \Pi_{R}^{Total}(s) = \frac{(sT)^2}{4s}(1-\alpha)\phi^2 \geq 0$. Therefore, when the price elasticities of demand in the foreign market is sufficiently high to satisfy the condition that $\phi < \sqrt{2}-1$, R&D investment in the NR regime is higher than or equal to in the R regime.

Appendix D: Proof of Result1

1) From equation (12) and (24), we can find that the condition $S_{NR} \geq (\leq)S_R$ holds, if and only if $\Pi_{NR}^{Total}(s) \geq (\leq)\Pi_{R}^{Total}(s)\ for\ \forall\ s$. When $\phi < \sqrt{2}-1$, from proposition 1 the condition $S_{NR} \geq S_R$ holds. When $\phi \geq \sqrt{2}-1$, by introducing α=0 into equation (7) and (19), we obtain $\Pi_{NR}^{Total}(s) - \Pi_{R2}^{Total}(s) = \frac{(sT)^2}{8s}(1-\phi)^2 \geq 0$. Threfore, when alll the bargaining power resides with the domestic firm ($\alpha = 0$), R&D investment in the NR regime is higher than or equal to in the R regime.

2) When $\phi < \sqrt{2}-1$, by introducing α=1 into equation (7), we obtain $\Pi_{NR}^{Total}(s) = \Pi_{R1}^{Total}(s) = \frac{(sT)^2}{4s}$. When $\phi \geq \sqrt{2}-1$, by introducing α=1 into equation (7) and (19), we obtain $\Pi_{NR}^{Total}(s) = \Pi_{R2}^{Total}(s) = \frac{(sT)^2}{4s}$. Therefore, when alll the bargaining power resides with the foreign government($\alpha = 1$), R&D investment is the same in the NR regime and the R regime.

Appendix E: Proof of Result2

1) From equation (12) and (24), we can find that the condition $S_{NR} \geq (\leq)S_R$ holds, if and only if $\Pi_{NR}^{Total}(s) \geq (\leq)\Pi_{R}^{Total}(s)\ for\ \forall\ s$. Note that $\phi = \frac{1}{2} > \sqrt{2}-1$. By introducing $\phi = \frac{1}{2}$ into equation (7) and (19), we obtain $\Pi_{NR}^{Total}(s) - \Pi_{R2}^{Total}(s) = \frac{(sT)^2}{32s}(1-\alpha)^2 \geq 0$. Therefore, when the price elasticities of demand in the foreign market satisfies the condition that $\phi = \frac{1}{2}$, R&D investment in the NR regime is higher than or equal to in the R regime.

2) Note that $\phi = 1 > \sqrt{2}-1$. By introducing $\phi = 1$ into equation (7) and (19), we obtain $\Pi_{NR}^{Total}(s) - \Pi_{R2}^{Total}(s) = -\frac{(sT)^2}{4s}(1-\alpha)(\sqrt{1+\alpha^2}-1) \leq 0$. Therefore, when the price elasticities of demand in the foreign market satisfies the condition that $\phi = 1$, R&D investment in the R regime is higher than or equal to in the NR regime.

Appendix F: Proof of Result3

1) By introducing $\phi = \frac{3}{4}$ into equation (7) and (19), we obtain

$$\Pi_{R2}^{Total}(s) - \Pi_{NR}^{Total}(s) = \frac{(sT)^2}{256s}(1-\alpha)f_{\phi=\frac{3}{4}}(\alpha),$$

where

$$f_{\phi=\frac{3}{4}}(\alpha) \equiv \Psi_{\phi=\frac{3}{4}}(\alpha) - \Theta_{\phi=\frac{3}{4}}(\alpha),$$

and

$$\Psi_{\phi=\frac{3}{4}}(\alpha) \equiv 5\sqrt{25+18\alpha+25\alpha^2},$$

$$\Theta_{\phi=\frac{3}{4}}(\alpha) \equiv 11\alpha + 27.$$

In addition, we can show that $f_{\phi=\frac{3}{4}}(0) = -2 < 0$, $f_{\phi=\frac{3}{4}}(1) = 2 > 0$,

$$\Psi'_{\phi=\frac{3}{4}}(\alpha) = \frac{5(25\alpha+9)}{\sqrt{25+18\alpha+25\alpha^2}} > 0,$$

and

$$\Psi''_{\phi=\frac{3}{4}}(\alpha) = \frac{2720}{(25+18\alpha+25\alpha^2)^{\frac{3}{2}}} > 0.$$

If α=1, we can find that $\Pi^{Total}_{R2}(s) = \Pi^{Total}_{NR}(s)$. If $0 \leq \alpha < 1$, the value of $\Pi^{Total}_{R2}(s) - \Pi^{Total}_{NR}(s)$ has the same sign as the value of $f_{\phi=\frac{3}{4}}(\alpha)$. Due to the properties of $f_{\phi=\frac{3}{4}}(\alpha)$, $\Psi_{\phi=\frac{3}{4}}(\alpha)$ and $\Theta_{\phi=\frac{3}{4}}(\alpha)$ summarized above, we can show that there exists a unique $\hat{\alpha}_{\phi=\frac{3}{4}} \in (0,1)$ such that satisfies the condition that $f_{\phi=\frac{3}{4}}(\alpha) \leq 0$ if $\alpha \leq \hat{\alpha}_{\phi=\frac{3}{4}}$, and $f_{\phi=\frac{3}{4}}(\alpha) \geq 0$ if $\alpha \geq \hat{\alpha}_{\phi=\frac{3}{4}}$ and $f_{\phi=\frac{3}{4}}(\hat{\alpha}_{\phi=\frac{3}{4}}) = 0$. Therefore, R&D investment in the R (NR) regime is higher than or equal to under the NR (R) regime, if $\alpha \geq (\leq)\hat{\alpha}_{\phi=\frac{3}{4}}$.

2)By introducing $\phi = \frac{7}{8}$ into equation (7) and (19), we obtain

$$\Pi^{Total}_{R2}(s) - \Pi^{Total}_{NR}(s) = \frac{(sT)^2}{1024s}(1-\alpha)f_{\phi=\frac{7}{8}}(\alpha),$$

where

$$f_{\phi=\frac{7}{8}}(\alpha) \equiv \Psi_{\phi=\frac{7}{8}}(\alpha) - \Theta_{\phi=\frac{7}{8}}(\alpha),$$

and

$$\Psi_{\phi=\frac{7}{8}}(\alpha) \equiv 13\sqrt{169+50\alpha+169\alpha^2},$$

$$\Theta_{\phi=\frac{7}{8}}(\alpha) \equiv 27\alpha + 171.$$

In addition, we can show that $f_{\phi=\frac{7}{8}}(0) = -2 < 0$, $f_{\phi=\frac{7}{8}}(1) = 13\sqrt{388} - 198 > 0$,

$$\Psi'_{\phi=\frac{7}{8}}(\alpha) = \frac{13(169\alpha+25)}{\sqrt{169+50\alpha+169\alpha^2}} > 0,$$

and

$$\Psi''_{\phi=\frac{7}{8}}(\alpha) = \frac{13[(13)^4 - 5^4]}{(169+50\alpha+169\alpha^2)^{\frac{3}{2}}} > 0.$$

If α=1, we can find that $\Pi_{R2}^{Total}(s) = \Pi_{NR}^{Total}(s)$. If $0 \le \alpha < 1$, the value of $\Pi_{R2}^{Total}(s) - \Pi_{NR}^{Total}(s)$ has the same sign as the value of $f_{\phi=\frac{7}{8}}(\alpha)$. Due to the properties of $f_{\phi=\frac{7}{8}}(\alpha)$, $\Psi_{\phi=\frac{7}{8}}(\alpha)$ and $\Theta_{\phi=\frac{7}{8}}(\alpha) \in (0,1)$ summarized above, we can show that there exists a unique $\hat{\alpha}_{\phi=\frac{7}{8}}$ such that satisfies the condition that $f_{\phi=\frac{7}{8}}(\alpha) \le 0$ if $\alpha \le \hat{\alpha}_{\phi=\frac{7}{8}}$, and $f_{\phi=\frac{7}{8}}(\alpha) \ge 0$ if $\alpha \ge \hat{\alpha}_{\phi=\frac{7}{8}}$ and $f_{\phi=\frac{7}{8}}(\hat{\alpha}_{\phi=\frac{7}{8}}) = 0$. Therefore, R&D investment in the R (NR) regime is higher than or equal to under the NR (R) regime, if $\alpha \ge (\le)\hat{\alpha}_{\phi=\frac{7}{8}}$.

3)From Result 3-1 and 3-2, $f_{\phi=\frac{3}{4}}(\alpha)$ is monotonically increasing in α at $\forall\ \alpha \in (0,1)$ and $f_{\phi=\frac{3}{4}}(0) = -2 < 0$, $f_{\phi=\frac{3}{4}}(1) = 2 > 0$. $f_{\phi=\frac{7}{8}}(\alpha)$ is also monotonically increasing in α at $\forall\ \alpha \in (0,1)$ and $f_{\phi=\frac{7}{8}}(0) = -2 < 0$, $f_{\phi=\frac{7}{8}}(1) = 13\sqrt{388} - 198 > 0$. Thus suppose there exists $\exists\ \acute{\alpha} \in (0,1)$ which satisfies the condition that $f_{\phi=\frac{3}{4}}(\acute{\alpha}) < (>)0$ and $f_{\phi=\frac{7}{8}}(\acute{\alpha}) > (<)0$, we can show that the condition $\hat{\alpha}_{\phi=\frac{3}{4}} > \hat{\alpha}_{\phi=\frac{7}{8}}$ $(\hat{\alpha}_{\phi=\frac{3}{4}} < \hat{\alpha}_{\phi=\frac{7}{8}})$ holds. By introducing $\alpha = 0.4$ into $f_{\phi=\frac{3}{4}}(\alpha)$ and $f_{\phi=\frac{7}{8}}(\alpha)$, we can find that $f_{\phi=\frac{3}{4}}(0.4) = -1.3168 < 0$ and $f_{\phi=\frac{7}{8}}(0.4) = 9.2779 > 0$. Therefore, we can show that the value of $\hat{\alpha}_{\phi=\frac{7}{8}}$ is smaller than the value of $\hat{\alpha}_{\phi=\frac{3}{4}}$.

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Table 1 The difference in R&D investment between the R regime and NR regime (S_R-S_{NR})

	Φ=0	Φ=0.1	Φ=0.2	Φ=0.3	Φ=0.4	Φ=0.5	Φ=0.6	Φ=0.7	Φ=0.8	Φ=0.9	Φ=1
α=0	0.00	0.00	-0.02	-0.04	-0.07	-0.05	-0.03	-0.02	-0.01	0.00	0.00
α=0.1	0.00	0.00	-0.02	-0.04	-0.07	-0.05	-0.03	-0.02	-0.01	0.00	0.00
α=0.2	0.00	0.00	-0.02	-0.04	-0.06	-0.05	-0.03	-0.01	0.00	0.00	0.00
α=0.3	0.00	0.00	-0.02	-0.04	-0.06	-0.05	-0.03	-0.01	0.00	0.01	0.01
α=0.4	0.00	0.00	-0.01	-0.03	-0.06	-0.04	-0.02	-0.01	0.00	0.01	0.01
α=0.5	0.00	0.00	-0.01	-0.03	-0.05	-0.04	-0.02	-0.01	0.00	0.01	0.02
α=0.6	0.00	0.00	-0.01	-0.02	-0.04	-0.03	-0.02	-0.01	0.01	0.01	0.02
α=0.7	0.00	0.00	-0.01	-0.02	-0.03	-0.03	-0.02	0.00	0.01	0.02	0.02
α=0.8	0.00	0.00	-0.01	-0.01	-0.02	-0.02	-0.01	0.00	0.01	0.01	0.02
α=0.9	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.01	0.01
α=1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00