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Citation of this paper:

Zhong, Hai. "2006-5 Price Control, Different Demands between Countries, and Parallel Trade in Pharmaceuticals." Economic Policy Research Institute. EPRI Working Papers, 2006-5. London, ON: Department of Economics, University of Western Ontario (2006).

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by

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Working Paper # 2006-5 **September 2006**

Western

RBC Financial Group
Economic Policy Research Institute
EPRI Working Paper Series

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Price Control, Different Demands between Countries, and Parallel Trade in Pharmaceuticals

HAI ZHONG*

September, 2006

Abstract

In recent years, there have been growing concerns on the issue of parallel trade on pharmaceuticals. It is an existing issue in European Union and an emerging issue in the North America and Asia. In this paper, a model is developed to explore the impact of parallel trade on: 1) profits of pharmaceutical firms, 2) drug price, supply and social welfare in the importing country, and 3) drug price, supply and social welfare in the exporting country. The possible policy reactions of the governments in the two countries are also discussed. By relaxing some assumptions, I extend the existing studies to a more general framework. I found that firm's total profits and social welfare in the importing country may increase or decrease. This finding is contradicted to an existing study because of the relaxation on some assumptions. Parallel trade will lead to a higher drug price and then a social welfare loss in the exporting country; under certain circumstances, the pharmaceutical firm may cut off the drug supply. The results show that the negotiated price in the presence of parallel trade is sensitive to the market size of the drug and transaction cost of parallel trade. Therefore, those factors have important policy implications to the policy maker in the exporting country. For the importing country, the social welfare change when parallel trade is legally permitted is closely related to the firm's bargaining power in the foreign market, which should be considered by the policy maker.

JEL classification: I11; I18; F1
Keywords: Prescription drugs; Price control; Parallel trade

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1. Introduction

In most industrialized countries, the GDP share of total health care costs has grown rapidly in recent years. Among the health care costs, pharmaceutical cost has increased at a more rapid rate than that of any others. Therefore, more and more attention is being been paid to pharmaceutical issues.

Pharmaceutical prices vary significantly between countries, even among those at the same level of development. This price disparity derives mainly from two sources: 1) the difference in pharmaceutical price regulations between countries 2) the difference in the demand for pharmaceuticals between countries.

In recent years, governments have become more and more involved in the financing of health care. Under increasing budgetary pressures, governments have strong incentives to reduce health care and pharmaceutical costs. Pharmaceutical price control in many countries is a reflection of this situation. Pharmaceutical price control can take many forms, such as direct price control (as in Canada, France, Italy and Spain), reference pricing, compulsory licensing (as in Canada before 1987), and others. Price control is commonly believed to be an important factor that leads to the pharmaceutical price discrepancy between countries. For example, pharmaceutical prices in Canada have been regulated by the Patented Medicine Price Review Board (PMPRB) since 1987. Meanwhile, there is no such regulation in the U.S. During that same period, the average U.S. price for patented drugs has been 36 percent to 67 percent higher than the average Canadian price[1]. Although differences in the health care systems, income levels and other country-specific factors could contribute to this price discrepancy, many researchers believe that price regulation in Canada plays an important role.

At the same time, countries vary in the characteristics of their health care systems, income levels, and other country-specific factors such as physician and patient behaviours, also population health status. These factors lead to differing demands for pharmaceuticals between countries and hence to the differences in drug prices.

The arbitrage opportunity resulting from price discrepancies opens the door to parallel trade. Parallel trade is the importation of pharmaceuticals from a country where prices are low to a country where price are high without the authorization of a trademark, copyright, or patent holder. Parallel trade is legally permitted inside the European Union. For example, in the United Kingdom, the Department of Health encourages pharmacists to buy parallel imports when they are cheaper than domestic products. Fifteen percent of domestic pharmaceutical consumption is imported from Spain and Italy. Parallel trade is used as a policy tool to contain pharmaceutical costs in the health care system. Although parallel trade is not legally permitted in North America, it is an emerging issue. Because of the price discrepancy between the United States and Canada, more and more Americans buy their prescription drugs from Canadian pharmacies, either by on-line ordering or organized tours. As a result of public outrage over the drug price differential between the two countries, in 2000, the US congress passed the *Medicine Equity and Drug Safety Act*, which would allow Canadian drugs to be re-imported into the US. President Clinton vetoed the legislation, ostensibly for safety reasons. However, this remains an important policy issue both in the US and Canada, reflected, for example, in

[1] See the article "Prescription Drug Prices in Canada: What Are the Lessons for the U.S.?" by Gross D. Available at (7/1/2005): http://www.aarp.org/international/Articles/a2003-07-11-ia-perspectives.html

Health Canada's suppression of internet pharmacies in 2004, and another round of hot debate on the same issue in the 2004 presidential election campaign in the U.S.

The presence of parallel trade in pharmaceuticals causes strategic reactions of pharmaceutical firms, which raise several interesting questions: 1) the change of firm's profits in the presence of parallel trade 2) drug price, supply and social welfare in the importing country 3) drug price, supply and social welfare in the exporting country

With this paper, I would like to contribute to the ongoing analysis and debate over issues related to parallel trade, and pay particular attention to the above three questions. I will explicitly take into account the feature of different demands on pharmaceuticals between countries, and pharmaceutical price control in the exporting country. The analysis will be conducted through a two-stage game approach, in which the first stage is a Nash bargaining game on the drug price between the pharmaceutical firm and the government in the exporting country, and the second stage is a Cournot competition between the firm and parallel trader in the importing country.

The analysis is organized as follows. In the next section, I will review a few studies related to my work. The third section presents my model. The final section contains my conclusions, policy implications, and discussion.

2. Literature Review

The literature is not large, but it has been growing rapidly in recent years. To date, most of these are studies from a policy perspective without a rigorous theoretical foundation. I review the three theoretical studies most related to my work.

Pecorino (2002)

This paper is a direct response to the legislative debate about whether the US should allow low price prescription drugs to be reimported from Canada. In this paper, a model is developed in which a drug is sold in both a foreign and a home country. When parallel trade is not allowed, the monopolistic pharmaceutical firm sets MR equal to MC in its home market to determine the optimal price, and the price in the foreign country is the solution of a Nash Bargaining game between the firm and the foreign government; given by

$$\underset{P^*}{Max}[kCS(p^*)]^{\alpha}[k\pi(p^*)]^{1-\alpha}, \qquad (*)$$

where CS is the consumer surplus in the foreign country, and π is the firm's profit in the foreign country. The author assumes that the demands in the two countries are identical in all aspects except size, which is reflected by a scaling factor k. α measures the bargaining power of the foreign government. When parallel trade is permitted, the author assumes that there will be a uniform price in the two markets. This price is the solution to the problem

$$\underset{P^*}{Max}[kCS(p^*)]^{\alpha}[(1+k)\pi(p^*)-\pi^m]^{1-\alpha}, \quad (**)$$

Here, $(1+k)\pi(p^*)$ is the firm's total profit in both markets under the uniform price, and π^m is the firm's profit if the drug is sold only in the home market, with no supply to the

foreign country. Pecorino analyses two different cases: linear demand and constant elasticity of demand. In both cases, the author finds that both the firm's profit and the domestic consumer surplus rise when parallel trade is legally permitted. That is because the firm bargains harder on the price under parallel trade. That implies the negotiated price under parallel trade has to be higher than in the absence of parallel trade, otherwise, there will be no supply to the foreign market.

There are two important assumptions in this model. First, the assumption of identical demands in the two countries is crucial to the conclusion about the firm's profit. The author has made this assumption based on the fact that the countries (EU, Canada, Japan, etc.) in question are all highly developed countries with similar levels of income. Therefore, the drug price discrepancy between countries occurs only because of drug price control. However, price control is only one of the reasons that lead to drug price discrepancy between countries; different demand between them is also an important factor. For example, the drug price discrepancy between Portugal and U.K is caused not only by price regulation, but also by differences in income between the two countries. Furthermore, in considering the different characteristics of health care systems and drug insurance coverage (public and private), identical demands (i.e. same demand elasticity and maximal willingness to pay) between countries is a questionable assumption, even for those countries at the same level of development. Therefore, identical demand can only be regarded as a special case. Second, the assumption of uniform price in both countries in the presence of parallel trade may also be unrealistic. Price in the importing country is related to the parallel trader's costs, a fact that has important policy implications. And also, the parallel trader has to face the price competition from the manufacture in the importing country.

Ganslandt and Maskus (2004)

In this paper, the authors develop a model in which a manufacturer competes in its home market with parallel trade firms. The home country is the high price country and the foreign country is the low price country. In the foreign country, the pharmaceutical prices are regulated. A distinct feature of this model is that multiple parallel traders jointly choose the maximum amount of parallel trade. It is a three stage game. At the first stage, n symmetric parallel importers enter the market, applying for a license from the authority in the home country at a cost T. Parallel traders will enter the market if the expected profit is non-negative. At the second stage, each parallel trader chooses its own quantity based on the regulated price in the foreign country and the transaction cost t. At the final stage, the manufacturer sets its price in the home country by taking into account the amount of parallel trade. The model is solved by backward induction. If the trade costs (T and t) are not too high, the manufacturer will accommodate the parallel trade. The equilibrium number of parallel traders and quantity of parallel trade can be found. The price in the home market is lower than in the absence of parallel trade. Using data from Sweden, the authors found that the prices of drugs subject to competition from parallel trade fell relative to other drugs over the period 1994-1999. The econometric analysis confirms the theoretical prediction.

The most important feature of this model is the limited quantity of parallel trade. The quantity is jointly determined by the manufacturer and parallel traders. This will not

lead to a uniform price in two countries under parallel trade as is assumed in Pecorino. Therefore, it makes the model more realistic.

Nevertheless, this analysis is "one-sided". The authors consider only the price change and the reactions of the interested parties in the home market. They do not examine the impact of parallel trade on the foreign market (i.e. the price and supply of the drug, and social welfare). Moreover, this analysis ignores the influence of foreign demand (and hence manufacturer's profit in the foreign market) on the manufacturer's decision in the home market, as well as the interaction between the foreign government and the manufacturer.

Jelovac and Bordoy (2005)

In this paper, the authors consider the changes of price and welfare after parallel trade is legally permitted. There are two important features of their model. First, the two countries have different demands. Country *i*'s demand is $D_i = \theta_i - \alpha_i p_i$, where θ_i reflects the different value that consumers put on the drug and α_i reflects the difference in the patients' level of co-payment. Second, the consumer puts a lower value on the reimported drug than on the one originally offered by the manufacturer, so their prices are not the same. The model is a three stage game. At the first stage, the firm maximizes its profit by taking into account parallel trade. At the second stage, the parallel importer sets a price to maximize his profit. At the final stage, the consumers in each country choose to consume one unit of the drug supplied either by the monopolist or by the parallel trader, depending on the price. The game is solved by backward induction. The equilibrium has several interesting characteristics. First, prices tend to converge under parallel trade, that is, the price in the low price (exporting) country is higher and the price in the high price (importing) country is lower than without parallel trade. Second, the effect of parallel trade on the total welfare is ambiguous except for a few extreme cases. Third, the different co-payment rates have an influence on parallel trade.

Modifying two aspects of this model may have important implications for the impact of parallel trade. The first is price regulation. In Jelovac and Borday assume that the firm can freely set a price. However, many studies argue that low price (which gives the incentive to parallel trade) is the result of price regulation. When a firm reacts to parallel trade under circumstances of price regulation, and its power to set a price is limited, the story might be different. Second, in this paper, the total welfare is defined as $TW = CS_A + CS_B - PE_A - PE_B + \pi_m + \pi_w$, where PE is the public expenditure paid by the government, and the last two terms are the profit of the monopolist firm and parallel trader. However, in the long run, total welfare is much more difficult to define if we take into account some other concerns such as R&D of pharmaceuticals.

In general, among the existing studies, very few have focused attention on the low price (exporting) country. Their analyses deal mainly with the price and welfare in the importing country. However, if parallel trade were legally permitted, the consequences for the low price country are also very important. Parallel trade will affect the profits of the pharmaceutical industry, and the reactions of that industry could have an impact on the national pharmaceutical price control system, on the drug supplies, and more generally on price negotiations between the pharmaceutical industry and each government. If a compromise on price cannot be reached, the pharmaceutical

manufacturer may cut off the supply of the drug to that market. For example, Danzon (1998) notes that Glaxo delayed for several years to launch its antimigraine product sumatriptan (Imigran®) in France, rather than accepting a low price that would have undercut its higher price elsewhere.

The model I develop below makes a series of contributions:

(1) I consider the impact of parallel trade on drug price, supply, and associated social welfare in the low-price (exporting) country; social welfare in the importing country; and the firm's total profit.

(2) I consider not only price control in the low-price country, but also the influence of the different characteristics of the demand in the two markets on the question of a firm's decision, its profit and the equilibrium price in the exporting country.

(3) I consider in more detail on possible policy reactions of the government in the low-price country and explore potential policy options for the high-price country.

3. A Model of Parallel Trade

Assumptions

I assume that there are two countries, H and L. A monopolistic pharmaceutical manufacturer produces and sells a patented drug in both H and L. The pharmaceutical prices are regulated in country L. The price of this drug in country H (p_H) is higher than the price in country L (p_L). The manufacturer is located in H. For simplicity, it is assumed that the firm produces at zero cost. In addition, the demands for this drug are different in the two countries. Demand is $q = 1 - p_H$ in country H, and $q_L = \alpha - p_L$ in country L. p_H and p_L are the price of this drug in country H and country L respectively. α is assumed to be smaller than 1, so that the monopoly price in country H is higher than the monopoly price in country L. Since the two demands have same slopes, α is an unambiguous measure of market size. These demand specifications are tractable and allow me to determine the influence of market size. Without parallel trade, the firm acts as a profit-maximizing monopolist in country H, setting its marginal revenue equal to the marginal cost. For the given demand function, the monopoly price for the firm is ½, q is ½ and profit (π^m) is ¼. In country L, pharmaceutical price is lower than that in country H. The price in country L is determined in a bargaining process between the firm and the government of country L. If parallel trade is allowed, the parallel trader purchases the drug in country L at the negotiated price p_L , and ships it to country H with a transaction cost t. This t is assumed to be less than ½, since parallel trade is clearly impossible if it is higher. In contrast to the assumption of multiple parallel traders in Ganslandt and Maskus (2004), I assume a single parallel trader. Once again, this is for the ease of calculation[2]. Under parallel trade, total sales in country H are $q = q_H + q_T$, where q_H is the quantity sold by the firm and q_T is the quantity sold by the parallel trader. The profit of the parallel trader is denoted π_T; the profit of the firm in country H under parallel trade is denoted π_H and its profit in country L is denoted π_L .

[2] This simplification does not change the direction of the fundamental conclusions.

An equilibrium under parallel trade consists of the quantities q_L, q_H and q_T and the prices p_L and p_H. The equilibrium is obtained in two stages. In the first stage, the firm and the government in country L negotiate the price of the drug p_L, which is the solution of a generalized Nash Bargaining game. In the second stage, in country H, the monopolist and the parallel trader engage in Cournot competition which determines the equilibrium price p_H and the quantities q_H and q_T.[3] The firm and the parallel trader, taking each other's sale as given, choose their own sales so as to maximize their own profits. The price p_H is the highest price at which all of the drug can be sold. Also, q_L is the quantity of goods demanded by the consumers in country L when the price is p_L. As usual, the equilibrium is solved by backward induction.

Cournot Competition in Country H

Under parallel trade, the firm's profit in market H is $\pi_H = p_H q_H + p_L q_T$. The first term is the profit made from the firm's own sale in market H, and the second term is the profit made from the sale to the parallel trader. The parallel trader buys this drug at p_L in country L and sells it at p_H in country H. Given the demand functions, the firm's profit is

$$\pi_H = \left[1-(q_H + q_T)\right] q_H + p_L q_T \tag{1}$$

The parallel trader's profit is

$$\pi_T = \left[1-(q_H + q_T) - p_L - t\right] q_T \tag{2}$$

The firm and the parallel trader, taking each other's sale as given, choose their own sales so as to maximize their own profits. Solving out the Cournot equilibrium,

$$q_H = \begin{cases} \dfrac{1+p_L+t}{3} & \text{if} \quad p_L \le \dfrac{1}{2} - t \\ \dfrac{1}{2} & \text{otherwise} \end{cases} \tag{3}$$

$$q_T = \begin{cases} \dfrac{1-2(p_L+t)}{3} & \text{if} \quad p_L \le \dfrac{1}{2} - t \\ 0 & \text{otherwise} \end{cases} \tag{4}$$

If the price of the drug in country L is higher than $\frac{1}{2} - t$, there would be no parallel trade because the acquisition cost to the parallel trader is too high.

[3] The idea is that the parallel trader and the firm have to compete with each other. We can change the assumption as the firm being a Stackberg leader, which will change the specific solutions of the model, but it does not change the direction of the conclusion.

The highest price p_H at which all of the goods can be sold is:

$$p_H = \begin{cases} \dfrac{1+p_L+t}{3} & \text{if} \quad p_L \le \dfrac{1}{2}-t \\ \dfrac{1}{2} & \text{otherwise} \end{cases} \tag{5}$$

Substituting equation (3), (4) and (5) into equation (1), the firm's profit in country H is

$$\pi_H = \begin{cases} \left[(1+p_L+t)^2+3p_L(1-2p_L-2t)\right]/9 & \text{if} \quad p_L \le \dfrac{1}{2}-t \\ \dfrac{1}{4} & \text{otherwise} \end{cases} \tag{6}$$

Parallel trade keeps π_H below ¼ until the price in market L is high enough to drive out the parallel trader. As p_L approaches $\frac{1}{2}-t$ from below, q_H, p_H and π_H converge to the monopoly solution while q_T and π_T converge to zero. There are no discontinuities in any of the variables when the parallel trade drops out of the market.

The firm's profit in country L is

$$\pi_L = \begin{cases} (\alpha-p_L)p_L & \text{if} \quad p_L \le \alpha \\ 0 & \text{otherwise} \end{cases} \tag{7}$$

The firm's total profit in both markets is $\pi = \pi_H + \pi_L$. Clearly, π_L is increasing in α and is maximized at $p_L = \frac{\alpha}{2}$. Differentiation shows that π_H is increasing in p_L and t when $p_L \le \frac{1}{2}-t$.

$$\frac{\partial \pi_H}{\partial p_L} = (5-10p_L-4t)/9 > 0 \quad \text{if} \quad p_L \le \frac{1}{2}-t \tag{8}$$

$$\frac{\partial \pi_H}{\partial t} = (2-4p_L+2t)/9 > 0 \quad \text{if} \quad p_L \le \frac{1}{2}-t \tag{9}$$

Functions π_L and π_H are both continuous; π_L is concave over the domain $0 \le p_L \le \alpha$, and π_H is concave over the entire domain. And π_H is always kinked at $p_L = \frac{1}{2}-t$.

First Stage

At the first stage, the firm and the government in country L negotiate the price p_L. Like Pecorino (2002), I assume that the negotiated price is determined by a generalized Nash bargaining game. The pay-off of the government in country L is the consumer surplus gained by the consumers if the good is made available in market L, and the firm's pay-off is the difference between its profits if it sells in both markets (π) and its profit if it sells only in market H (π^m). If they agree on a price, that price maximizes a weighted geometric average of their pay-offs, where the weights reflect bargaining power. If the firm cannot attain profits of at least π^m by selling in both markets, it will not agree to sell in market L.

The price chosen is determined by the following generalized Nash bargaining game:

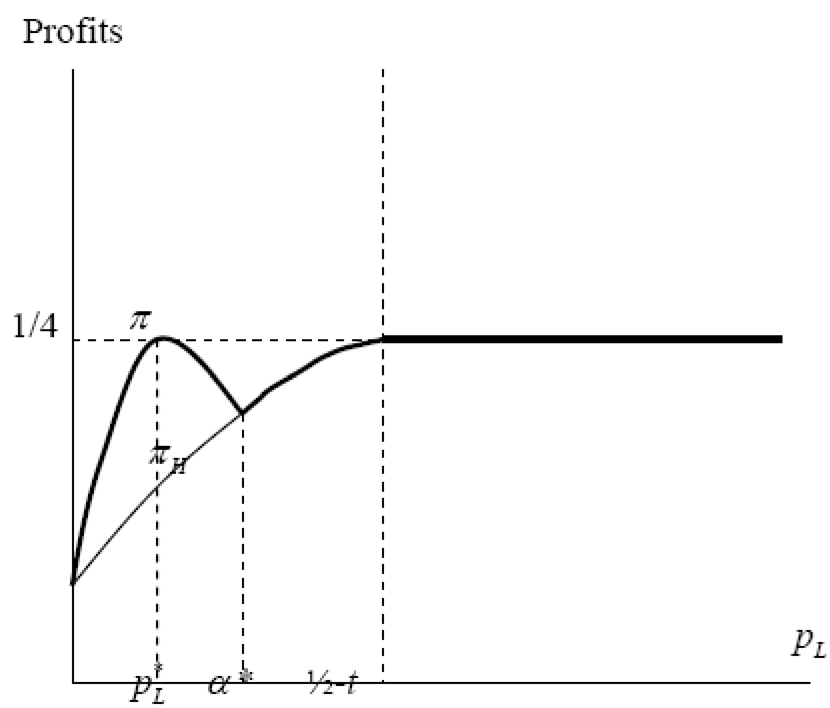
$$\underset{p_L}{Max}[CS(p_L)]^{\gamma}\left[\pi(p_L)-\pi^m\right]^{1-\gamma} \qquad (10)$$

where

$$\text{CS}(p_L)=\frac{1}{2}(\alpha - p_L)^2 \qquad (11)$$

In equation (10), γ is the bargaining power of the government in country L ($0<\gamma<1$); π^m is ¼.

Figure-1, circumstances of no agreement between the firm and government L



For every γ, there are some circumstances in which there will be no agreement between the firm and government L. If the market size in country L (α) is so small that the firm's best profits when it sells in both markets are smaller than π^m, the firm will cut off the supply to market L. This situation is illustrated by Figure 1.

There are some α (smaller than $\frac{1}{2}-t$) such that the firm's best profits when it sells in both markets under parallel trade are just equal to π^m. Call this value α^* and let p_L^* be the associated profit-maximizing price.[4] If α falls below α^*, profits in both markets are smaller than π^m at every p_L that is smaller than α. Since the firm's maximal total profits in the two markets are smaller than π^m, the firm will cut off the supply to market L. If α rises above α^*, profits are greater at every p_L that is smaller than α, and there will be an agreement that benefits both parties. Henceforth α will be assumed to lie between α^* and 1 so that there is an agreement.

Next, I analyze the equilibrium in three different cases: $\gamma = 0$, $\gamma = 1$ and $0 < \gamma < 1$.

Case 1: $\gamma = 0$

When $\gamma = 0$, all the bargaining power resides with the firm. The generalized Nash Bargaining game simplifies to the firm's profit maximization. The firm acts as a monopolist in market L and can freely choose the price p_L to maximize π. There are two components in the firm's total profit π: profit in market L (π_L) and profit in market H (π_H). Based on equation (6) and (7), the solution of the firm's profit maximization is

$$p_L = \begin{cases} \dfrac{\alpha}{2} & \text{if} \quad \alpha > 1-2t \\ \dfrac{1}{2}-t & \text{if} \quad 1-\dfrac{8}{3}t < \alpha < 1-2t \\ \dfrac{(5+9\alpha-4t)}{28} & \text{if} \quad \alpha < 1-\dfrac{8}{3}t \end{cases} \tag{12}$$

The intuition behind equation (12) is as follows.

(a) The monopoly price in market L is $\frac{\alpha}{2}$. If $\frac{\alpha}{2}$ is greater than $\frac{1}{2}-t$, the profit function looks like that in Figure 2. The firm maximizes its profits by charging the monopoly price in both markets; the gap between the two monopoly prices is too small to allow the parallel trader to operate.

[4] The firm's best profit is achieved when it has all the bargaining power and can freely choose the price to maximize its profits. In this context, by setting $\pi_L + \pi_H = 1/4$, we can find $\alpha^* = \left[2\sqrt{14(5/4-t^2-2t)}-5+4t\right]/9$

(b) If $\frac{\alpha}{2}$ is between $\frac{1}{2}-\frac{4}{3}t$ and $\frac{1}{2}-t$, the profit function looks like that in Figure 3. When the price p_L exceeds $\frac{\alpha}{2}$, the firm's profit in market L begins to fall, but the firm's profit in market H increases since the higher p_L reduces the quantity of parallel trade. The increase of π_H outweighs the fall of π_L. Therefore, the optimal price for the firm "hangs up" at $\frac{1}{2}-t$.

(c) If $\frac{\alpha}{2}$ is smaller than $\frac{1}{2}-\frac{4}{3}t$, the profit function looks like that in Figure 4. The optimal price for the firm is $p_L = (5+9\alpha-4t)/28$. When the price p_L exceeds $\frac{\alpha}{2}$, the firm's profit in market L begins to fall, but its profit in market H increases. The fall of π_L is smaller than the increase of π_H if $p_L < (5+9\alpha-4t)/28$, and greater than the increase of π_H if $p_L > (5+9\alpha-4t)/28$. At $p_L = (5+9\alpha-4t)/28$, the absolute values of the slopes of π_L and π_H are equal. Therefore, the optimal price for the firm is $p_L = (5+9\alpha-4t)/28$.

Figure-2, large market in country L

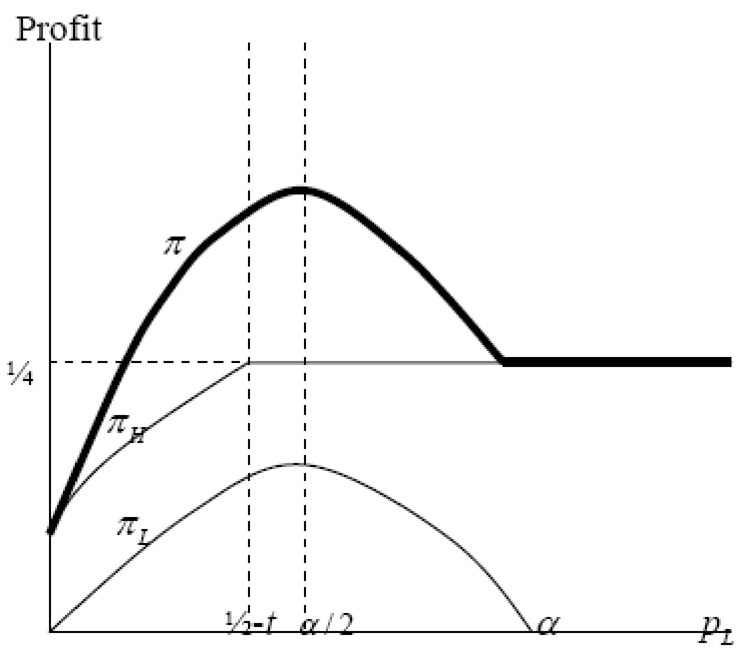


Figure-3, middle case

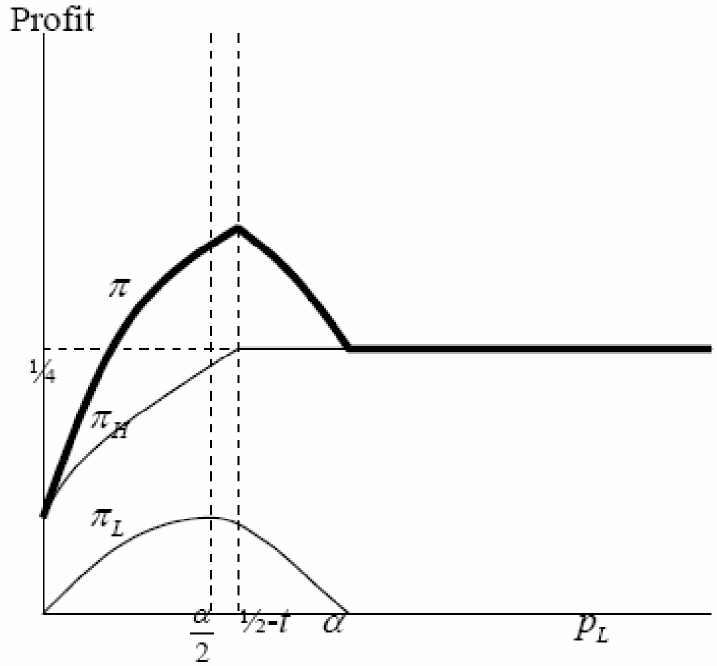
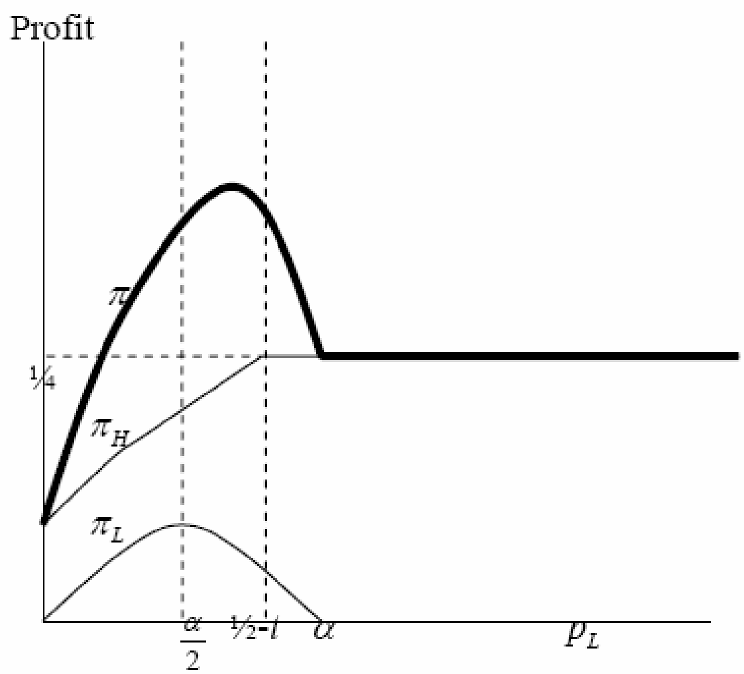


Figure-4, small market in country L



How does the price vary with α and t? An examination of equation (12) shows that $\frac{\partial p_L}{\partial \alpha}$ is positive as long as $p_L \neq \frac{1}{2} - t$, and $\frac{\partial p_L}{\partial t}$ is positive so long as there is parallel trade.

An increase in α for a given t increases the equilibrium price p_L except when α is still in the range of $1 - \frac{8}{3}t < \alpha < 1 - 2t$, over which the equilibrium price p_L hangs up at $1/2 - t$. A larger market size allows the firm to charge a higher price. In Figure 2 and Figure 4, an increase in α increases the slope of π_L and hence π at each p_L, so that the stationary point lies farther to the right: equilibrium p_L rises with α. Whenever α is still in the range of $1 - \frac{8}{3}t < \alpha < 1 - 2t$, the analysis in part (b) above continues to hold. Therefore, the equilibrium price p_L hangs up at $1/2 - t$.

Similarly, a decrease in t (for a given α) in the presence of parallel trade makes the graph of π_H and then π steeper at each p_L, shifting the stationary point to the right, so that the equilibrium price rises as the transaction cost falls. A falling transaction cost increases competition from the parallel trader, so the firm raises p_L to limit the parallel trader's activity.

What are the effects of a change in α or t on the firm's total profits? Recall that $\frac{\partial \pi}{\partial \alpha} = \frac{\partial \pi_L}{\partial \alpha} > 0$ whenever p_L is less than α. Likewise, $\frac{\partial \pi}{\partial t} = \frac{\partial \pi_H}{\partial t} > 0$ whenever there is parallel trade. An increase of α increases the firm's profit in market L at each p_L smaller than α, and hence the firm's maximal total profits must also rise. Under parallel trade, an increase of t reduces the quantity of parallel trade, so that the firm's profit in market H increases. When $p_L = \frac{1}{2} - t$, the increase of t means that the firm could charge a lower price that is closer to the monopoly price $\alpha / 2$ in market L, so that the firm's profit in market L increases. The increase of t shifts the graph of π upward at each p_L smaller than $\frac{1}{2} - t$, so long as p_L is initially below $\frac{1}{2} - t$. Consequently, the firm's maximal profits rise.

The consumer surplus in country L is given by equation (11). Differentiation shows that

$$\frac{\partial CS(p_L)}{\partial \alpha} = (\alpha - p_L)(1 - \frac{\partial p_L}{\partial \alpha}) > 0 \qquad (13)$$

$$\frac{\partial CS(p_L)}{\partial t} = (\alpha - p_L)(-\frac{\partial p_L}{\partial t}) < 0 \qquad (14)$$

whenever there is parallel trade. Since $\frac{\partial p_L}{\partial \alpha}$ is always smaller than one, an increase of α in country L must increase the consumer surplus. Similarly, since an increase of *t* in the presence of parallel trade decreases the equilibrium price p_L, it must increase the consumer surplus in country L.

<u>Case 2:</u> $\gamma = 1$

When $\gamma = 1$, all the bargaining power resides with the government in country L. From equation (10), we can see that the problem is simplified to the maximization of consumer surplus in country L. The government in country L will choose the lowest price that the firm will accept, which is the price that sets $\pi - \pi^m = 0$:

$$p_L = \left[(5+9\alpha-4t) - \sqrt{(5+9\alpha-4t)^2 + 56(t^2+2t-\frac{5}{4})} \right] / 28 \qquad (15)$$

This p_L is the point at which the profit function π in Figure 2, 3 and 4 cuts the line with height ¼. An increase of α or *t* shifts the graph of π upward; therefore, the intersection of the profit function π and line of ¼ moves left. The new equilibrium price is lower than before.[5] If the market size in country L is bigger, the firm's lowest acceptable price would be lower. A larger market in country L make it easier for the firm to compensate its profit loss in country H. Higher transaction costs reduce the quantity of parallel trade and hence the profit loss in country H; therefore, the firm's lowest acceptable price in market L is decreasing in *t*. Since the consumer surplus in country L is increasing in α and decreasing in p_L, a larger α or *t* increases consumer surplus.

<u>Case 3:</u> $0 < \gamma < 1$

When the bargaining power is between 0 and 1, we should have the same three cases as we saw when the firm has all the bargaining power. When the market size is large and firm has high bargaining power, the equilibrium p_L could be large enough to prohibit parallel trade. When the market size is relatively small and the firm has low bargaining power, the equilibrium p_L is below $\frac{1}{2} - t$, the firm accommodates parallel trade. The intermediate case is that the firm chooses a price hanging up at $\frac{1}{2} - t$. It is difficult to explicitly solve out the equilibrium price for the general case. But we can explore the property of the equilibrium price as follows. If the price is greater than or equal to $\frac{1}{2} - t$, there will be no parallel trade. Therefore, I focus my analysis only on the

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[5] The effects of a change in α or *t* on the equilibrium price p_L can also be shown by differentiations, please see the details in Appendix 1 and Appendix 2.

case where the price is smaller than $\frac{1}{2}-t$, i.e. the firm accommodates parallel trade. The first and second order conditions of equation (10) are

$$\gamma CS'(p_L)\left[\pi(p_L)-\pi^m\right]+(1-\gamma)\pi'(p_L)CS(p_L)=0 \qquad (16)$$ [6]

$$\Gamma \equiv \gamma CS''(p_L)\left[\pi(p_L)-\pi^m\right]-CS'(p_L)\pi'(p_L)+(1-\gamma)\pi''(p_L)CS(p_L)<0 \qquad (17)$$

where the prime denotes a derivative. Totally differentiating equation (16), we get

$$\frac{dp_L}{d\gamma}=\frac{-CS'(p_L)\left[\pi(p_L)-\pi^m\right]+\pi'(p_L)CS(p_L)}{\Gamma}<0 \qquad (18)$$

The negotiated price is decreasing in the bargaining power of the government of country L.

$$\frac{dp_L}{dt}=\frac{-\gamma CS'(p_L)\frac{d\pi(p_L)}{dt}-(1-\gamma)CS(p_L)\frac{d\pi'(p_L)}{dt}}{\Gamma}<0 \qquad (19)$$

The negotiated price is decreasing in the transaction cost of the parallel trader. With a higher transaction cost, the quantity of parallel trade is lower; this means a smaller profit loss in the high price market; therefore, the firm is more willing to accept a lower negotiated price in the low price market.

$$\frac{dp_L}{d\alpha}=\frac{-\gamma\left[\pi(p_L)-\pi^m\right]\frac{dCS'(p_L)}{d\alpha}-\gamma CS'(p_L)\frac{d\pi(p_L)}{d\alpha}-(1-\gamma)\frac{d\pi'(p_L)}{d\alpha}CS(p_L)-(1-\gamma)\pi'(p_L)\frac{dCS(p_L)}{d\alpha}}{\Gamma} \qquad (20)$$

Hence $\lim_{\gamma\to 1}\frac{dp_L}{d\alpha}<0$ and $\lim_{\gamma\to 0}\frac{dp_L}{d\alpha}>0$. That means that a larger market size leads to a lower negotiated price if the government in country L has high bargaining power. With a larger market size in country L, it is easier for the firm to recover the profit lost in country H. Therefore, the firm is more willing to accept a lower price in the negotiation. When the firm has high bargaining power, it will try to take advantage of price discrimination and charge a higher price. A relatively larger market will be more likely to accept a higher price.

[6] The result is based on equations (6) and (7) but expressed in general equation form for simplicity.

The effects of a change in γ, α or t on a firm's total profit are shown by the differentiations:

$$\frac{d\pi}{d\gamma} = \pi'(p_L)\frac{dp_L}{d\gamma} < 0 \qquad (21)$$

$$\frac{d\pi}{d\alpha} = p_L + \pi'(p_L)\frac{\partial p_L}{\partial \alpha} > 0 \qquad (22)$$

$$\frac{d\pi}{dt} = \frac{\partial \pi_H}{\partial t} + \pi'(p_L)\frac{\partial p_L}{\partial t} > 0 \qquad (23)$$

The firm's profit is decreasing in the bargaining power of government L, and increasing in the market size and the transaction costs to parallel trader. For the firm, the benefits from an increase of α or t depend on its bargaining power. In both equation (22) and (23), the first term is positive and the second term is negative. $\pi'(p_L)$ is greater than zero in the relevant range. $\pi'(p_L) = 0$ is only possible when the firm has all bargaining power. Equations (22) and (23) are minimized to zero when the firm has zero bargaining power. The firm's profit is ¼ whatever the α or t is. As the firm's bargaining power goes up, the equilibrium price p_L also goes up, and then $\pi'(p_L)$ is smaller. Therefore, the second terms in both equations are less negative.

Because the effect of a change in t on consumer surplus in country L is entirely determined by its effect on p_L, a larger t increases consumer surplus. If the government in country L has most of the bargaining power, consumer surplus is increasing in α. If the firm has most of the bargaining power, consumer surplus is also increasing in α since $\frac{\partial p_L}{\partial \alpha}$ is always smaller than one.

A comparison between parallel trade and no parallel trade regimes

In the above analysis, we assume parallel trade is legally permitted in both countries L and H. In this section, at first, I assume that parallel trade is not legally permitted, and then compare firm's profits and social welfare of the two countries if parallel trade is legally permitted.

When there is no parallel trade, the firm and the government in country L solve

$$\underset{p_L^{NT}}{Max}\left[CS(p_L^{NT})\right]^{\gamma}\left[\pi_L(p_L^{NT})\right]^{1-\gamma} \qquad (24)$$

where I denote the equilibrium price under no parallel trade regime as p_L^{NT}, for the given demand, the solution of equation (24) is

$$p_L^{NT} = \frac{\alpha(1-\gamma)}{2} \tag{25}$$

The corresponding profit is

$$\pi^{NT} = \frac{1}{4} + \frac{\alpha^2(1-\gamma^2)}{4} \tag{26}$$

If the two countries move from no parallel trade regime to parallel trade regime, we are interested on the changes of firm's profits and social welfare. In country L, if the only concern of the government is consumer surplus, we just need to find out the change of equilibrium prices between two regimes. In the presence of parallel trade, in order to compensate the firm's profit loss in country H, there must be an increase of price in country L, $\Delta p_L = p_L - p_L^{NT} > 0$. And the magnitude of Δp depends on the bargaining power of each party.

$$\frac{d\Delta p_L}{d\gamma} = \frac{d(p_L - p_L^{NT})}{d\gamma} = \frac{dp_L}{d\gamma} + \frac{\alpha}{2} > 0 \tag{27}$$ [7]

From the analysis in the last section, we know when $\gamma = 0$, there is an increase of the equilibrium price in market L in the presence of parallel trade, and we also know $\frac{d\Delta p_L}{d\gamma} > 0$; therefore, for any given value of γ, there is an increase of the negotiated price in the presence of parallel trade ($\Delta p_L > 0$). The increase of price has two effects: increasing firm's profit in country L, and reducing the quantity of parallel trade. Therefore, the consumer surplus falls, and then the social welfare in country L is lower under parallel trade. The higher the bargaining powers of the government in country L, the larger the change in the equilibrium price, and hence the consumer surplus. Therefore, parallel trade undermines the high bargaining power of the government in country L.

For $0 < \gamma < 1$, the impact of parallel trade on firm's profit is ambiguous. Differentiating $\Delta\pi$ with respect to γ, we have

$$\frac{d\Delta\pi}{d\gamma} = \frac{d(\pi - \pi^{NT})}{d\gamma} = \frac{d\pi}{d\gamma} - \left(-\frac{\gamma\alpha^2}{2}\right) \tag{28}$$

where $\frac{d\pi}{d\gamma} = \pi'(p_L)\frac{dp_L}{d\gamma} < 0$

The firm's profit is decreasing in the bargaining power of government L in both regimes: with or without parallel trade. Therefore, both the first and second term in equation (28)

[7] Please see the proof in appendix 3

are negative. From the above analysis, we know the impact of parallel trade on the firm's profit at two extreme cases. When the firm has all bargaining power ($\gamma = 0$), it suffers a profit loss. The firm cannot fully take the advantage of price discrimination in the presence of parallel trade. When the firm has no bargaining power at all ($\gamma = 1$), its profit is unchanged in the presence of parallel trade. Therefore, we have

$$\lim_{\gamma \to 0} \frac{d\Delta\pi}{d\gamma} < 0 , \ \lim_{\gamma \to 1} \frac{d\Delta\pi}{d\gamma} = 0 \qquad (29)$$

The firm tends to have a larger profit when it has high bargaining powers ($\gamma \to 0$), since its ability of price discrimination is undermined by the parallel trade. If the firm's bargain power is low ($\gamma \to 1$), the impact of parallel trade on firm's profit is small.

Under parallel trade, the consumer surplus in country H is higher. The quantity of supply goes up and price goes down with parallel trade. If the social welfare in country H is simply defined as the sum of firm's profit and consumer surplus, it could be higher under parallel trade when the firm has low or no bargaining power in country L. When the firm has high bargaining power in country L, the consumer surplus in country H is still higher, but the firm will suffer higher profit loss; therefore, the effect on total social welfare in country H is ambiguous.

A summary of the results is presented in Table 1.

4. Conclusion, Policy Implications, and Discussion

In the presence of parallel trade, the pharmaceutical firm has to compete with the parallel trader in the high price market so that the profit of the firm in the high price market falls. In order to compensate for the loss in the high price market, the firm will bargain harder with the government in the low price country, and the price of the drug in the low price country will rise. If the market size in country L is so small that the firm's best profits when it sells in both markets are smaller than π^m, the firm will cut off the supply to market L. Therefore, there will be a social welfare loss incurred from parallel trade.

When the demands are different in the two markets and the pharmaceutical firm has high bargaining power in the price negotiation, the firm's profits fall because its ability to price discriminate is undermined by parallel trade. The firm's total profit is maximized if it can fully take advantage of price discrimination. The result of an increasing of the firm's profits in Pecorino (2002) is the outcome of identical demands in two markets, which implies that the only source of price differential is from price regulation. However, when the price differential results not only from price regulation, but also from different demands in the two markets, the firm suffers a profit loss under parallel trade.

When the firm earns very little profit from the low price market because of low bargaining power, the impact of parallel trade on its profit won't be large. Under parallel trade, the consumer surplus in the high price country goes up since the price of the drug is lower. Therefore, the short run social welfare in the high price country could be higher if the firm's bargaining power in the low price country is low.

Policy Implications

The government in country L

If the market size of the drug in country L is too small, the firm may cut off the drug supply to country L. The decision is sensitive to α and t. If the market size is large enough and the firm decides to accommodate parallel trade, as shown in the last section, the negotiated price is also sensitive to α and t. Therefore, those factors have policy implications for the government in country L.

When the government in country L has high bargaining power, the firm's minimum acceptable price in the presence of parallel trade is decreasing in α. The government in country L has the power to influence α. For example, the government could subsidize the target population of the drug in the question, manipulate the consumer's insurance status and co-payment rates, and put the drug on the formulary of a public drug plan. Those actions will increase the maximal willingness to pay and decrease the demand elasticity for the drug, so that the market will be more important and attractive to the firm; therefore, it will be willing to accept a lower price in the negotiation. When the government in country L has low bargaining power, the firm's optimal price in the presence of parallel trade is increasing in α. If the goal is a lower price level, the government in country L could remove the drug from the formulary of a public drug plan, or reduce the subsidy to the target population of this drug. A more straightforward option in all cases is to manipulate the transaction cost to the parallel trader. This action could achieve the same goal on the negotiated price without affecting the demand and supply of the drug. An increase in the unit transaction cost to the parallel traders will reduce the amount of parallel trade, and subsequently lead to a lower price which is acceptable to the firm. One option is a unit tax (or regulation fee) on the parallel exportation.

The government in country H

Before the presence of parallel trade, when the government in country L has all the bargaining power, the firm obtains very little profit from market L. In the presence of parallel trade, in order to induce the firm to supply the drug, the government in country L has to offer a higher price. The firm's total profit is the same as before. However, the consumer surplus is increased in country H. That is similar to a transfer of consumer surplus from country L to country H. The social welfare is higher in country H in the presence of parallel trade. Therefore, if the drug price is strictly regulated in country L, legalization of parallel trade could be a policy option for the government in country H to undermine the foreign drug price regulation.

Before the presence of parallel trade, if the firm has high bargaining power in the low price country and the demands are different in the two markets, the firm can take the advantage of price discrimination to maximize its profit. If parallel trade is legalized in the high price country, the firm's capacity for price discrimination is undermined. Therefore, it will suffer a profit loss. But the consumer surplus in country H will go up. The total short run effect on social welfare is ambiguous. If we take into account considerations of the firm's R&D, the long-run social welfare in country H is unknown. Therefore, the policy maker should be cautious about the legalization of parallel trade.

Discussion

There are several questions that need to be explored further in the future.

Country L's social welfare function

In this paper, I consider a very basic form of short-run social welfare function for the government in country L in which includes only consumer surplus. However, the policy maker very rarely uses such a social welfare function. In reality, there are many other concerns in the price negotiation process, such as the need for research and development of pharmaceuticals, containing health care cost and maybe some other vague political factors. It is difficult to clearly define a social welfare function if we take into account these long run concerns. Moreover, the social welfare function could change in the presence of parallel trade. For example, the social welfare function may contain considerations about the R&D of pharmaceuticals before the presence of parallel trade. However, in the presence of parallel trade, consumer surplus may become the only concern of the policy maker in country L because of the higher drug price and budgetary pressure. If the social welfare function has other components before the presence of parallel trade, the negotiated price is not the lowest price that the firm will accept. For example, when the bargaining power all resides with the government in country L, the equilibrium price would be higher than the firm's marginal cost. If this is the case, the social welfare in country L is not necessarily worse off in the presence of parallel trade.

The Profit of the Parallel Trader

Country L also has the opportunity to increase social welfare by extracting profits from the parallel trader. To induce the firm to continue supplying to market L, the negotiated price in the presence of parallel trade has to be increased. This will lead to a certain level of social welfare loss, however, if the loss can be compensated by the profit extracted from the parallel trader, country L could still be better off.

Bargaining Power

In this study, we assume that the bargaining power is exogenous. In the presence of parallel trade, the bargaining power may become endogenous. The impact of parallel trade on the bargaining power of each party in the negotiation needs to be further explored.

Appendix

1. $\dfrac{\partial p_L}{\partial \alpha} = \dfrac{9}{28}\left\{1 - \dfrac{(5+9\alpha-4t)}{\sqrt{(5+9\alpha-4t)^2 + 56(t^2+2t-\frac{5}{4})}}\right\}$

$\because \alpha > 0$, $t < \dfrac{1}{2}$

$\Rightarrow 5+9\alpha-4t > 1$

and $t^2 + 2t - \dfrac{5}{4} < 0$

$\Rightarrow \dfrac{(5+9\alpha-4t)}{\sqrt{(5+9\alpha-4t)^2 + 56(t^2+2t-\frac{5}{4})}} > 1$

Therefore

$\dfrac{\partial p_L}{\partial \alpha} < 0$

2. $\dfrac{\partial p_L}{\partial t} = -\dfrac{4}{28}\left\{1 - \dfrac{(5+9\alpha-4t)-14(t+1)}{\sqrt{(5+9\alpha-4t)^2 + 56(t^2+2t-\frac{5}{4})}}\right\}$

$\because \dfrac{(5+9\alpha-4t)-(5+9\beta)(t+1)}{\sqrt{(5+9\alpha-4t)^2 + 4(5+9\beta)(t^2} + 2t - \frac{5}{4})} < -1$ (As shown below)

$\therefore \dfrac{\partial p_L}{dt} < 0$

$$\frac{(5+9\alpha-4t)-14(t+1)}{\sqrt{(5+9\alpha-4t)^2 + 56(t^2+2t-\frac{5}{4})}} < -1$$

Proof:

$\because$ $[(5+9\alpha-4t)-14(t+1)]^2 - [(5+9\alpha-4t)^2 + 56(t^2+2t-\frac{5}{4})]$

$\Rightarrow t^2 - 2\alpha(t+1) + (t^2+2t+1) > 0$, because $\alpha < 1$

$\therefore$ $|(5+9\alpha-4t)-14(t+1)| > \sqrt{(5+9\alpha-4t)^2 + 56(t^2+2t-\frac{5}{4})}$

Because of the same condition $\alpha < 1$, we have

$$(5+9\alpha-4t)-14(t+1)<0$$

$$\therefore \frac{(5+9\alpha-4t)-(5+9\beta)(t+1)}{\sqrt{(5+9\alpha-4t)^2+4(5+9\beta)(t^2+2t-\frac{5}{4})}}<-1$$

3. $\dfrac{d\Delta p_L}{d\gamma}=\dfrac{d(p_L-p_L^{NT})}{d\gamma}=\dfrac{dp_L}{d\gamma}+\dfrac{\alpha}{2}$ is minimized at $\gamma=1$ when $0<\gamma<1$

Since

$$\frac{d(\frac{dp_L}{d\gamma})}{d\gamma}=\frac{-\left\{Q(p_L)\left[\pi(p_L)-\pi^m\right]+\pi'(p_L)CS(p_L)\right\}.\left\{\beta\left[\pi(p_L)-\pi^m\right]-\pi''(p_L)CS(p_L)\right\}}{\Gamma^2}<0$$

we know

$$\lim_{\gamma\to 1}\frac{d\Delta p_L}{d\gamma}>0$$

Therefore

$$\frac{d\Delta p_L}{d\gamma}>0 \text{ for } 0<\gamma<1$$

Table-1, summary of results

	γ	α			t		
		$\gamma=0$	$\gamma=1$	$0<\gamma<1$	$\gamma=0$	$\gamma=1$	$0<\gamma<1$
p_L	$\downarrow$	$\uparrow$	$\downarrow$	Decided by γ	$\downarrow$	$\downarrow$	$\downarrow$
CS	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$
π	$\downarrow$	$\uparrow$	-	$\uparrow$	$\uparrow$	-	$\uparrow$

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