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PARALLEL TRADE AND REIMBURSEMENT REGULATION

Laura Birg
Parallel Trade and Reimbursement Regulation

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Abstract

This paper studies interaction of pharmaceutical regulation and parallel trade in a North-South framework. An innovative firm located in the North can sell its drug only in the North or in both countries. Governments may limit reimbursement for the drug. Reimbursement limits reduce the firm’s incentive to supply the South, with the threat of withdrawal from the South being larger if both countries regulate as compared to only the South limiting reimbursement. Stricter regulation, i.e. a lower reimbursement limit in the Northern country increases the incentive to sell in the South. Under parallel trade, the welfare maximizing reimbursement limit in the North is lower than under segmented markets, while the reimbursement limit in the South is not affected. If both countries cooperate in reimbursement policies, both of them adopt less strict reimbursement regimes. Cooperation results in a decrease in social welfare in the North but in an increase in welfare in the South.

JEL classification: F12, I11, I18
Keywords: pharmaceutical regulation, reimbursement limit, parallel trade

1 Introduction

Parallel trade refers to trade in goods, which were placed on the market in one country and which then are exported to another country without the authorization of the manufacturer (Maskus, 2000). In the European Union¹, the regional exhaustion of intellectual property rights and the free movement of goods allow parallel traders to import goods from another country without the authorization of the manufacturer, i.e. engage in parallel trade (Maskus, 2000). A precondition for this form of arbitrage are significant

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¹More precisely, parallel trade is allowed within the European Economic Area, which includes the European Union plus Norway and Switzerland.
price differences between countries, which make parallel importing profitable. Price differences may stem from (pharmaceutical) manufacturers’ price discrimination between different countries and/or differences in national pharmaceutical regulations in the individual member states (Kanavos et al., 2004; Enemark et al., 2006). For pharmaceuticals, price differences of up to 100%-300% can be observed in the European Union (Kanavos & Costa-Font, 2005). Typical source countries of parallel imports are low price-countries with strict price regulation, such as Greece, Italy, Portugal, and Spain, while destination countries are high price-countries, characterized by relatively free price setting, such as Denmark, Germany, the Netherlands, and Sweden (Kanavos & Costa-Font, 2005). In 2012, pharmaceutical parallel trade had a volume of € 5.5 bn (EFPIA, 2014). In the destination countries, the share of parallel imports in pharmacy market sales ranged between 10.2% in Germany, 14.8% in the Netherlands, 18.9% in Sweden, and 23 % in Denmark (EFPIA, 2014).

The occurrence of parallel trade in pharmaceuticals is closely linked to regulation. Parallel trade takes place in highly regulated markets. The increase in public health expenditure has induced a number of government interventions (Maynard & Bloor, 2003). Consequently, pharmaceuticals markets are characterized by a variety of regulatory instruments that are partly overlapping and impede each other (see Espin & Rovira, 2007 for an overview of regulatory interventions in the European Union). In general, pharmaceutical regulation follows two approaches: On the supply side, regulatory instruments such as price caps or maximum wholesale margins are intended to restrict monopoly pricing and reduce prices of covered products and services. On the demand side, instruments like reference prices or copayments aim at increasing price sensitivity and reducing reimbursement by the insurer. A commonly applied demand side instrument is the reference price system, where the reference price is the maximum reimbursement for a group of drugs. Firms may charge higher market prices than the reference price. In this case, if the market price exceeds the reference price, patients have to pay the difference between both prices out-of-pocket (Danzon, 2001). In the European Union, among others Austria, Belgium, Finland, France, Germany, Italy, Netherlands, Portugal, and Spain use reference price systems (Bongers & Carradinh, 2009).

According to the Treaty on the Functioning of the European Union (TFEU), Art. 168, the European member states decide on health policy, including pharmaceutical price regulation. Consequently, as pharmaceutical price regulation and reimbursement rules

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2The group of pharmaceuticals is defined in terms of interchangeability, either with respect to the active ingredient, the therapeutic category, or the therapeutic function (Lopez-Casanovas & Puig-Junoy, 2000).
are under exclusive national competence, EU member states differ in the regulatory instruments and in the strictness of regulation. And, since drug prices are directly or indirectly determined by regulation, the EU member states also show differences in drug prices. Consequently, by creating price differences, pharmaceutical regulation may trigger parallel trade.

At the same time, parallel trade may erode price differences. Drug prices may converge, as parallel trade limits the ability of pharmaceutical firms to price discriminate. In high price countries, parallel trade is then expected to reduce drug prices, on one hand by providing lower priced equivalents, on the other hand, through an indirect competitive effect, which results in manufacturers reducing drug prices. Empirical evidence on the price decreasing effect of parallel trade in destination countries is ambiguous. While some authors (Kanavos et al., 2004, Kyle, Allsbrook & Schulman, 2008) find no evidence for price competition generated by parallel trade or stronger price competition than in countries without parallel trade, others (West & Mahon, 2003, Ganslandt & Maskus, 2004, Granlund & Köksal, 2011) find that parallel trade may generate competitive pressure on drug prices.

Apart from direct adjustments of pricing policy, parallel trade may induce other changes of firm behavior: Firms may delay or even limit supply to low-price countries in order to (temporarily) retain high prices in other countries. Danzon, Wang & Wang (2005) who analyze launches of new drugs in 25 countries between 1994 and 1998, find that parallel exporting countries have fewer launches and longer launch delays. Using data on drug launches in the 28 largest pharmaceutical markets between 1980 and 2000, Kyle (2007) suggests that parallel trade delays launches into low price countries in Europe. Also other studies confirm that stricter regulation, which might be linked to the status as an source country of parallel imports, show longer launch delays. This suggests – as put forward by Bennato & Valletti (2014) – that export decisions is not

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4 Moreover, Danzon & Epstein (2008), Verniers, Stremerscha & Croux (2011), Costa-Font, McGuire & Varol (2014) suggest that stricter regulation and/or interdependence between countries lead to greater launch delays.
exogenous, but rather induced by parallel trade and regulatory decisions.

Also governments (in source countries of parallel imports) may change their behavior, if parallel trade takes place. Pecorino (2002), Grossman & Lai (2008), Bennato & Valletti (2014) argue that countries take their impact on firms’ decision to supply the respective country into account when setting price caps, thus abstaining from too strict regulation.\footnote{Parallel trade may also induce regulation: Many destination countries provide incentives for patients to purchase lower-priced parallel imports (via the cost-sharing mechanism) or legal requirements to dispense parallel imported drugs, which ensures the sale of parallel imports for parallel traders (Kanavos et al., 2004). In destination countries of parallel imports, the lower prices of parallel imports may reveal the information which price level is still profitable for manufacturers and regulatory authorities may adjust maximum prices downwards.}

Against this background this paper studies interaction of pharmaceutical regulation and parallel trade in a North-South framework. An innovative firm located in the North can sell its drug only in the North or in both countries. Governments limit reimbursement for the drug.

This paper focuses on reimbursement limits, first, because this instrument is commonly applied in the European Union. Second, the effect of reimbursement limits differs from that of price caps, as reimbursement limits have an effect on prices, but as price setting is free, reimbursement limits do not fully determine prices, that is, reimbursement limits do not translate to market prices. So, whereas under price caps, price setting is de facto assigned to governments, reimbursement limits allow to analyze the interaction between regulation and price setting.

Reimbursement limits reduce the firm’s incentive to supply the South, with the threat of withdrawal from the South being larger if both countries regulate as compared to only the South limiting reimbursement. Stricter regulation, i.e. a lower reimbursement limit in the Northern country increases the incentive to sell in the South. Under parallel trade, the welfare maximizing reimbursement limit in the North is lower than under segmented markets, while the reimbursement limit in the South is not affected. If both countries cooperate in reimbursement policies, both of them adopt less strict reimbursement regimes. Cooperation results in a decrease in social welfare in the North but in an increase in welfare in the South.

The rest of the paper is organized as follows. In the next section, the model is presented. Section 3 studies the effect of regulation on the export decision, section 4 analyzes the effect of parallel trade on regulation. Section 5 studies cooperation among governments, Section 6 analyzes the effect of no commitment of governments. Section 7 compares reimbursement limits to price caps. Section 8 concludes.
2 The Model

Consider an innovative firm selling a drug in two countries, North and South, \( j = N, S \). The firm is located in the North.

Each consumer demands either one or zero units of the drug. The utility derived from no drug consumption is zero. A consumer \( i \) in country \( j \) who buys one unit of drug obtains a net utility of

\[
U(\theta_{ij}, c_j) = \theta_{ij} - c_j,
\]

where \( \theta_{ij} \) is income and \( c_j \) country-specific drug copayment. Assume that, as in Roy & Saggi (2012), the parameter \( \theta \) is uniformly distributed over the interval \([0, \mu_j]\) in country \( j = N, S \) and that the number of consumers is \( \mu_j \) in country \( j \), where \( \mu N = \mu \geq \mu S = 1 \). This is, both countries differ in the distribution of the parameter \( \theta \) and in size. The parameter \( \theta \) can be interpreted as willingness to pay, for instance due to differences in the severity of the condition, prescription practices or insurance coverage (see e.g. Brekke, Holmas & Straume, 2011) or it can be interpreted as income.

In both countries, health insurance reimburses a fraction of the drug price, the remaining fraction \( \gamma_j \) is paid by the patient. This is, under no regulation, the drug copayment is \( c_j = \gamma_j p_j \). If reimbursement is limited to the amount \( r_j \), as under reference prices, the copayment is \( c^{R}_j = \gamma_j r_j + p_j - r_j \), where \( \gamma_j \) is the coinsurance rate and \( r_j \) the reimbursement limit in country \( j \).

Assume the following timing: In stage 1, governments in \( N \) and \( S \) set reimbursement limits to maximize welfare. In stage 2, the firm decides whether or not to export to country \( S \). In stage 3, the firm sets prices.

3 The Effect of Regulation on the Export Decision

3.1 No Regulation

Consider first the case without regulation when reimbursement is not limited. When parallel trade is not allowed, the firm can price discriminate and set country-specific prices \( p_j \) to maximize its (joint) profit

\[
\pi_N + \pi_S = \frac{(\mu - \gamma_N p_N)}{\mu} p_N + (1 - \gamma_S p_S) p_S.
\]

(1)

Equilibrium prices are

\[
p_N = \frac{\mu}{2 \gamma_N}, p_S = \frac{1}{2 \gamma_S}.
\]

(2)
Price differences between the two countries result from differences in market size and differences in coinsurance rates. For $\mu > \frac{\gamma_N}{\gamma_S}$, the price in North is higher than in South ($p_N > p_S$).

The firm’s profit is
\[ \pi_N + \pi_S = \frac{\mu}{4\gamma_N} + \frac{1}{4\gamma_S}. \tag{3} \]

If parallel trade is allowed, the firm sells to both markets at a uniform price $p_{N,S}$. Profit is
\[ \pi_{PT}^{N,S} = \left( \frac{\mu - \gamma_N p_{N,S}}{\mu} + (1 - \gamma_S p_{N,S}) \right) p_{N,S}. \tag{4} \]

The equilibrium price is
\[ p_{N,S} = \frac{\mu}{\gamma_N + \mu \gamma_S}. \tag{5} \]

For $\mu > \frac{\gamma_N}{\gamma_S}$, the uniform price is lower than the price in North and higher than the price in South ($p_N > p_{N,S} > p_S$). The firm’s profit is
\[ \pi_{PT}^{N,S} = \frac{\mu}{\gamma_N + \mu \gamma_S}. \tag{6} \]

The firm sells to the South under parallel trade ($\Delta = \pi_{N,S}^{PT} - \pi_N > 0$), if $\mu < 3\frac{\gamma_N}{\gamma_S}$, i.e. market size in the North is sufficiently small.

The firm sells only to the North under parallel trade ($\Delta < 0$). < $\gamma_S$, if $\mu > 3\gamma_N$, i.e. market size in the North is sufficiently large.

### 3.2 Regulation

Consider now the case when reimbursement is limited to $r_j < p_j^R$ in country $j$. In addition to the standard copayment $\gamma_j p_j^R$, consumers pay the difference between the price and the reimbursement limit $p_j^R - r_j$.

When parallel trade is not allowed, the firm can price discriminate and set country-specific prices $p_j$ to maximize its (joint) profit
\[ \pi_R^N + \pi_R^S = \left( \frac{\mu - (\gamma_N r_N + p_N^R - r_N)}{\mu} \right) p_N^R + (1 - (\gamma_S r_S + p_S^R - r_S)) p_S^R. \tag{7} \]

Equilibrium prices are
\[ p_N^R = \frac{\mu + r_N (1 - \gamma_N)}{2}, \quad p_S^R = \frac{1 + r_S (1 - \gamma_S)}{2}. \tag{8} \]

Assume $r_N \leq \frac{\mu}{\gamma_N+1}$ and $r_S \leq \frac{1}{\gamma_S+1}$ so that $p_N^R - r_N \geq 0$ and $p_S^R - r_S \geq 0$. 
For $\mu > r_S (1 - \gamma_S) - r_N (1 - \gamma_N) + 1$, the price in North is higher than in South ($p^R_N > p^R_S$).

The firm’s profit is

$$
\pi^R_N + \pi^R_S = \frac{(\mu + r_N (1 - \gamma_N))^2}{4\mu} + \frac{(\mu + r_S (1 - \gamma_S))^2}{4}.
$$

(9)

If parallel trade is allowed and only the South limits reimbursement, the firm maximizes

$$
\pi^{PT,R}_{N,S} = \left( \frac{\mu - \gamma_N p^R_{N,S}}{\mu} \right) + \left( 1 - \left( \gamma_S r_S + p^R_{N,S} - r^{PT,R}_S \right) \right) p^R_{N,S}.
$$

(10)

The equilibrium price is

$$
p^R_{N,S} = \frac{\mu \left( 2 + r^{PT,R}_S (1 - \gamma_S) \right)}{2(\gamma_N + \mu)}.
$$

(11)

The firm’s profit is

$$
\pi^{PT,R}_{N,S} = \frac{\mu \left( r^{PT,R}_N - \gamma_S r^{PT,R}_S + 2 \right)^2}{4(\gamma_N + \mu)}.
$$

(12)

The firm sells to the South under parallel trade ($\Delta^R = \pi^{PT,R}_{N,S} - \pi_N > 0$), if $\mu < 3\gamma_N + \gamma_N r^{PT,R}_S (1 - \gamma_S) \left( 4 + r^{PT,R}_S (1 - \gamma_S) \right)$, i.e. market size in the North is sufficiently small, or equivalently, if $r^{PT,R}_S > \frac{\sqrt{\gamma_N (\mu + \gamma_N) - 2\gamma_N}}{\gamma_N (1 - \gamma_S)}$, i.e. the reimbursement amount is sufficiently high and accordingly, regulation is sufficiently soft in the South. Vice versa, if market size in the North is sufficiently large or regulation in the South is sufficiently strict, the firm only sells to the North under parallel trade. Under regulation the incentive to sell in the South is lower ($\Delta > \Delta^R$). Stricter regulation, a lower reimbursement limit, lowers incentive to sell in $S$ ($\frac{\partial \Delta^R}{\partial r_S} > 0$), because it results in a lower uniform price under parallel trade and accordingly, it decreases the price difference between the price in the North and the uniform price and the profit from selling only in the North and the profit from selling in both countries.

If parallel trade is allowed and both countries limit reimbursement, the firm maxi-

\footnote{Assume $r_S \leq \frac{-2\mu}{2\gamma_N + \mu (1 + \gamma_S)}$ for $p^R_{N,S} - r_S \geq 0$.}
The equilibrium price is

\[ p_{N,S}^{RR} = \frac{2\mu + \mu r_{S}^{PT,RR} (1 - \gamma_{S}) + \mu r_{N}^{PT,RR} (1 - \gamma_{N})}{2 (\mu + 1)}. \]  

(14)

The firm’s profit is

\[ \pi_{N,S}^{PT,RR} = \frac{(2\mu + \mu r_{N}^{PT,RR} (1 - \gamma_{N}) + \mu r_{S}^{PT,RR} (1 - \gamma_{S}))^{2}}{4\mu (\mu + 1)}. \]  

(15)

The firm sells to the South under parallel trade \((\Delta^{RR} = \pi_{N,S}^{PT,RR}^{RR} - \pi_{N}^{RR} > 0)\), if \(\mu < \mu^{9}\), i.e. market size in the North is sufficiently small, if \(r_{S}^{PT,RR} > r_{S}^{PT,RR}^{10}\), i.e. regulation is sufficiently soft in the South, or \(r_{N}^{PT,RR} < r_{N}^{PT,RR}^{11}\), i.e. regulation is sufficiently strict in the North. Vice versa, if market size in the North is sufficiently large, regulation in the South is sufficiently strict, or regulation in the North is sufficiently soft, the firm only sells to the North under parallel trade. Regulation in both countries lowers the incentive to sell in the South as compared to regulation only in the South \((\Delta^{R} > \Delta^{RR})\). Stricter regulation in the North increases the incentive to sell in the South \((\frac{\partial \Delta^{RR}}{\partial r_{N}^{PT,RR}} < 0)\), because it decreases the price difference between the price in the North and the uniform price c.p. and accordingly, the change in profit from selling in the North due to parallel trade is lower. Stricter regulation in the South decreases the incentive to sell in the South \((\frac{\partial \Delta^{RR}}{\partial r_{S}^{PT,RR}} < 0)\).

Proposition 1 summarizes the effect of regulation on the decision to export:

**Proposition 1** Under regulation the incentive to sell in \(S\) is lower. Regulation in both \(N\) and \(S\) lowers the incentive to sell in \(S\) as compared to regulation only in \(S\). Stricter regulation in \(N\) increases the incentive to sell in \(S\), stricter regulation in \(S\) decreases the

---

8 Assume \(r_{N} \leq \frac{\mu (2 + r_{S}(1 - \gamma_{S}))}{\gamma_{N} + 2 \mu + 2}\) and \(r_{S} < \frac{2 \mu + r_{N}(1 - \gamma_{N})}{\mu + r_{S} + 2}\) for \(p_{N,S}^{RR} - r_{N} \geq 0\) and \(p_{N,S}^{RR} - r_{S} \geq 0\).

9 \(\mu^{*} = \frac{1}{2} r_{S}^{PT,RR} (1 - \gamma_{S}) \left( 4 + r_{S}^{PT,RR} (1 - \gamma_{S}) \right) - r_{N}^{PT,RR} (1 - \gamma_{N})^{6} \)

\[ + \frac{1}{2} \left( r_{S}^{PT,RR} (1 - \gamma_{S}) \left( 6 + r_{S}^{PT,RR} (1 - \gamma_{S}) \right) - 4 r_{S}^{PT,RR} (1 - \gamma_{N}) \right) + 9 \left( 1 + r_{S}^{PT,RR} (1 - \gamma_{S}) \right) + \frac{3}{2}. \]

10 \(r_{S}^{PT,RR} = \sqrt{\frac{\mu + r_{S}(1 - \gamma_{S}) - 2 \mu + r_{N}(1 - \gamma_{N})}{r_{N}(1 - \gamma_{N})}}. \)

11 \(r_{N}^{PT,RR} = \frac{1 - r_{N}^{PT,RR} (1 - \gamma_{S}) + r_{S}^{PT,RR} (1 - \gamma_{S})}{1 - \gamma_{N}}. \)
incentive to sell in S.

4 The Effect of Parallel Trade on Regulation

Consider now that governments set reimbursement limits to maximize national welfare.

Under no parallel trade, the government in the North maximizes the sum of consumer surplus and the firm’s profit less public pharmaceutical expenditure:

\[ W_R^N = CS_R^N - E_R^N + \pi^N = \frac{3\mu^2 + r_N (1 - \gamma_N) (2\mu - r_N (1 - \gamma_N))}{8\mu}. \]  

As welfare increases with the reimbursement limit, the government sets the highest possible reimbursement limit \(^{12}\):

\[ r_N = \frac{\mu}{\gamma_N + 1}. \]

Regulation increases welfare in N \((W_R^N > W_N)\).

Welfare in the South is given as consumer surplus less public expenditure:

\[ W_R^S = CS_R^S - E_R^S = \frac{(1 + r_S (1 - \gamma_S)) (1 - 3r_S (1 - \gamma_S))}{8}. \]

As welfare decreases with the reimbursement limit, the government in the South sets:

\[ r_S = 0. \]

This implies that patients pay the full price of the drug out-of-pocket. Also in the South, regulation increases welfare \((W_R^S > W_S)\).

Under parallel trade and regulation only in the South, welfare in the South is:

\[ W_S^{PT,R} = CS_S^{PT,R} - E_S^{PT,R} = \frac{(2\gamma_N + r_S (1 - \gamma_S) (2\gamma_N + \mu)) (2\gamma_N - r_S (1 - \gamma_S) (2\gamma_N + 3\mu))}{8 (\gamma_N + \mu)^2}. \]

The government in the South maximizes welfare subject to \(\Delta^R = \pi_{N,S}^{PT,R} - \pi_N \geq 0\), i.e.

\(^{12}\) Assume \(r_N \leq \frac{\mu}{\gamma_N + 1}\) and \(r_S \leq \frac{1}{\gamma_S + 1}\) so that \(p_{N}^R - r_N \geq 0\) and \(p_{S}^R - r_S \geq 0\).
the firm exporting to the South. For \( \mu < 3\gamma_N \), the government sets
\[
|r^{PT,R}_S|_{\mu<3\gamma_N} = 0, \tag{21}
\]
for \( \mu > 3\gamma_N \), the government sets
\[
|r^{PT,R}_S|_{\mu>3\gamma_N} = \frac{\sqrt{\gamma_N (\mu + \gamma_N)} - 2\gamma_N}{\gamma_N (1 - \gamma_S)}. \tag{22}
\]
Parallel trade does not affect the strictness of regulation, if the market (size) in the North is sufficiently small \( (r^{PT,R}_S)_{\mu<3\gamma_N} = r_S) \) and relaxes regulation, i.e. increases the reimbursement amount, if the market in the North is sufficiently large \( (r^{PT,R}_S)_{\mu>3\gamma_N} > r_S) \).

Under parallel trade, if both countries limit reimbursement, welfare is:
\[
W^{PT,RR}_N = \frac{4\mu^2 (2 + (\mu + 2)) + r_N (1 - \gamma_N) (4\mu (\mu + 2) - r_N (6\mu + 4\mu^2 + 1) (1 - \gamma_N))}{8\mu (\mu + 1)^2} + \frac{2\mu r_N (1 - \gamma_S) (2\mu + 3) (1 - \gamma_N)}{8\mu (\mu + 1)^2} + \frac{\mu^2 r_S (1 - \gamma_S) (4\mu (\mu + 2) + r_S (1 - \gamma_S) (2\mu + 3))}{8\mu (\mu + 1)^2}, \tag{23}
\]
\[
W^{PT,RR}_S = \frac{(2 - r_N (1 - \gamma_N) - r_S (1 - \gamma_S) (3\mu + 2)) (2 - r_N (1 - \gamma_N) + r_S (1 - \gamma_S) (\mu + 2))}{8(\mu + 1)^2}.
\]

The government in the South maximizes welfare subject to \( \Delta_R^{RR} = \pi^{PT,RR}_{N,S} - \pi^R_N \geq 0 \), i.e. the firm exporting to the South. For \( \mu \lesssim \bar{\mu}^{14} \), governments set
\[
|r^{PT,RR}_N|_{\mu\leq\bar{\mu}} = \frac{2\mu (\mu + 2)}{(1 - \gamma_N) (6\mu + 4\mu^2 + 1)}, \quad |r^{PT,RR}_S|_{\mu\leq\bar{\mu}} = 0, \tag{24}
\]
for \( \mu \gtrsim \bar{\mu} \), governments set
\[
|r^{PT,RR}_N|_{\mu\geq\bar{\mu}} = \frac{\mu (\sqrt{\mu + \bar{\mu}} (2\mu + 3) - 2 (\mu + 1))}{(1 - \gamma_N) (4 (\mu + 1)^2 - \sqrt{\mu + \bar{\mu}} (2\mu + 3))},
\]
\[
|r^{PT,RR}_S|_{\mu\geq\bar{\mu}} = \frac{\sqrt{\mu + \bar{\mu}} (8\mu + 4\mu^2 + 5) - 8\mu^2 - 14\mu - 6}{(1 - \gamma_S) (4 (\mu + 1)^2 - \sqrt{\mu + \bar{\mu}} (2\mu + 3))}. \tag{25}
\]

\(^{13}\)Note that \( r_S = \frac{\sqrt{\gamma_N (\mu + \gamma_N) - 2\gamma_N}}{\gamma_N (1 - \gamma_S)} \geq 0 \) for \( \mu \leq 3\gamma_N \).

\(^{14}\)\( \bar{\mu} = \bar{\mu} (\gamma_N) \) with \( \gamma_N = 0.1: \bar{\mu} = 0.97786, \gamma_N = 0.2: \bar{\mu} = 1.1855, \gamma_N = 0.25: \bar{\mu} = 1.2972. \)
Parallel trade may increase the strictness of regulation in the North, i.e. reimbursement amounts are lower, if the coinsurance rate is sufficiently low $(r_{PT,RR}^N|_{\mu \leq \widehat{\mu}} < r_N^N)$, if $\gamma_N < \gamma_N^{16}$, $r_{PT,RR}^N|_{\mu \geq \widehat{\mu}} < r_N^N$, if $\gamma_N < \gamma_N^{17}$. Parallel trade does not affect the strictness of regulation in the South, if the market in the North is sufficiently small $(r_{PT,RR}^S|_{\mu \leq \widehat{\mu}} = r_S^S)$ and relaxes regulation, i.e. increases the reimbursement amount, if the market in the North is sufficiently large $(r_{PT,RR}^S|_{\mu \geq \widehat{\mu}} > r_S^S)$.

Proposition 2 summarizes the effect of parallel trade on regulation.

**Proposition 2** Parallel trade makes increases the strictness of regulation in $N$, if the coinsurance rate is sufficiently low. Parallel trade does not affect the strictness of regulation in $S$, if the market in $N$ is sufficiently small and relaxes regulation, i.e. increases the reimbursement amount, if the market in $N$ is sufficiently large.

### 5 Cooperation Among Governments

Consider now that governments cooperate in setting reimbursement limits to maximize joint welfare.

For $\mu \leq \widehat{\mu} = 4\gamma_N^3 + 8\gamma_N + 3$, governments set

$$r_{PT,RR, C}^N|_{\mu \leq \widehat{\mu}} = \frac{2\mu}{(1 - \gamma_N)(\mu + 1)}, \quad r_{PT,RR, C}^S|_{\mu \leq \widehat{\mu}} = \frac{2\mu}{(1 - \gamma_S)(\mu + 1)}; \quad (26)$$

for $\mu > \widehat{\mu}$ governments set

$$r_{PT,RR, C}^N|_{\mu > \widehat{\mu}} = \frac{\mu (3\sqrt{\mu + 1} - 4)}{(1 - \gamma_N)(4(\mu + 1) - 3\sqrt{\mu + 1})},$$
$$r_{PT,RR, C}^S|_{\mu > \widehat{\mu}} = \frac{\sqrt{\mu + 1}(4\mu + 3) - 4(2\mu + 1)}{(1 - \gamma_S)(4(\mu + 1) - 3\sqrt{\mu + 1})}; \quad (27)$$

Independent of market size $\mu$, cooperation decreases reimbursement limits, i.e. relaxes regulation in the North $(r_{PT,RR, C}^N > r_{PT,RR}^N)$. For $\mu < \widehat{\mu}$, cooperation relaxes regulation in the South, for $\mu > \widehat{\mu}$, cooperation increases the strictness of regulation in the South $(r_{PT, RR, C}^S|_{\mu \leq \widehat{\mu}} > r_{PT,RR}^S|_{\mu \leq \widehat{\mu}}$, $r_{PT, RR, C}^S|_{\mu \geq \widehat{\mu}} > r_{PT,RR}^S|_{\mu \geq \widehat{\mu}}$, $r_{PT, RR, C}^S|_{\mu < \widehat{\mu}} < r_{PT,RR}^S|_{\mu \geq \widehat{\mu}})$. Independent of market size $\mu$, welfare in the North is higher under cooperation than under non-cooperative reimbursement setting, welfare in the South is

\footnotesize

16 \( \gamma_N^{16} = \frac{(2\mu + 3)(2\mu - 1)}{(\mu + 3)(\mu + 1)} \),

17 \( \gamma_N^{17} = \frac{(3\mu + 3)(\sqrt{\mu + 1})}{(\mu + 1)\sqrt{\mu + 1}} \).

\normalsize
lower under cooperation \((W^{{PT,RR}}_N (r^{{PT,RR,C}}_N, r^{{PT,RR,C}}_S) < W^{{PT,RR}}_N (r^{{PT,RR}}_N, r^{{PT,RR}}_S))\),
\((W^{{PT,RR}}_S (r^{{PT,RR,C}}_N, r^{{PT,RR,C}}_S) > W^{{PT,RR}}_S (r^{{PT,RR}}_N, r^{{PT,RR}}_S))\).

Proposition 3 summarizes the effect of cooperation.

**Proposition 3** Cooperation relaxes regulation in \(N\) and relaxes regulation in \(S\) for \(\mu < 10.657\) and increases the strictness of regulation in \(S\) otherwise. Cooperation increases welfare in \(N\) and decreases welfare in \(S\).

### 6 No Commitment

Consider now the case that governments cannot commit to setting reimbursement limits before the firm decides on exporting. So consider the following timing: In stage 1, the firm decides whether or not to export to country \(S\). In stage 2, governments in \(N\) and \(S\) set reimbursement limits to maximize welfare. In stage 3, the firm sets prices.

If the firm exports to the South, welfare in North and South is given as in equation (23). Governments set welfare maximizing reimbursement levels

\[
 r^E_N = \frac{2\mu (\mu + 2)}{(1 - \gamma_N) (6\mu + 4\mu^2 + 1)}, r^E_S = 0 \quad (28)
\]

The firm’s profit is

\[
 \pi^E = \frac{\mu (\mu + 1) (4\mu + 3)^2}{(4\mu^2 + 6\mu + 1)^2}. \quad (29)
\]

If the firm does not export to the South and only sells in the North, welfare in the North is given as 16. The government in the North sets the welfare maximizing reimbursement amount

\[
 r^{NE}_N = \frac{\mu}{\gamma_N + 1}. \quad (30)
\]

The firm’s profit is

\[
 \pi^{NE} = \frac{\mu}{(\gamma_N + 1)^2}. \quad (31)
\]

The firm decides to export, if \(\Delta^E = \pi^E - \pi^{NE} \ge 0\), if market size in the North is sufficiently small, \(\mu \lesssim \tilde{\mu}\) and if the coinsurance rate is sufficiently high, \(\gamma_N > \gamma_N^{20}\).

---

19**Note that** \(r^E_N\) is equivalent to \(r^{PT,NC}_N\) and \(r^E_S\) is equivalent to \(r^{PT,NC}_S\). The notation is framed in terms of "export" and "not export", because the focus of the analysis is the export decision. Similarly, \(\pi^E\) is equivalent to \(\pi^{PT,RR}_N\), \(r^E_N\) to \(r_N\), and \(\pi^{NE}\) to \(\pi^R_N\).

20**\(\gamma_N^{*} = \frac{\sqrt{\mu^2 + (4\mu + 3)^2} - (\mu + 1)(4\mu + 3)}{(\mu + 1)(4\mu + 3)}\).**
When comparing commitment and no commitment with respect to regulation, the firm’s profit and welfare, three cases can be distinguished.

First, for a sufficiently small market size in the North and a sufficiently high coinsurance rate in the North ($\mu \lesssim \bar{\mu}$ and $\gamma_N > \gamma^*_N$), it does not matter, whether governments can commit to setting reimbursement limits before the export decision, the firm exports to the South and market outcomes, regulation, the firm’s profit and welfare, under no commitment and commitment are the same.

Second, for a sufficiently small market size in the North and a sufficiently low coinsurance rate in the North ($\mu \lesssim \bar{\mu}$ and $\gamma_N < \gamma^*_N$), market outcomes under no commitment and commitment differ: Under commitment, the firm exports and governments set reimbursement limits as in equation (24), under no commitment, the firm does not export and the government in North sets a reimbursement limit as in equation (30). Without commitment, regulation in the North is less strict, i.e. the reimbursement amount is lower ($r_{N}^{\text{PT;RR}} < r_{N}^{\text{PT;NC}}$). Without commitment, the firm’s profit is higher ($\pi_N^{\text{PT;RR}} > \pi_N^{\text{PT;NC}}$) and welfare is lower ($W_N^{\text{PT;RR}} < W_N^{\text{PT;NC}}$). With commitment, the firm’s profit is higher ($\pi_N^{\text{PT;RR}} > \pi_N^{\text{PT;NC}}$) and welfare is lower ($W_N^{\text{PT;RR}} < W_N^{\text{PT;NC}}$).

Third, for a sufficiently large market size in the North ($\mu \gtrsim \bar{\mu}$), market outcomes under no commitment and commitment also differ: Under commitment, the firm exports and governments set reimbursement limits in the North ($r_{N}^{\text{PT;RR}} < r_{N}^{\text{PT;NC}}$). Without commitment, regulation in the North is less strict, i.e. the reimbursement amount is higher ($r_{N}^{\text{PT;RR}} > r_{N}^{\text{PT;NC}}$) if $\gamma_N > \gamma_{\text{NS2}}$ and welfare is lower ($W_N^{\text{PT;RR}} < W_N^{\text{PT;NC}}$). Without commitment, if $\gamma_N < \gamma_{\text{NS2}}$, the firm’s profit is lower ($\pi_N^{\text{PT;RR}} < \pi_N^{\text{PT;NC}}$) if $\gamma_N > \gamma_{\text{NS2}}$ and welfare is higher ($W_N^{\text{PT;RR}} > W_N^{\text{PT;NC}}$). The proposition summarizes the effect of no commitment.

**Proposition 4** If governments cannot commit to setting reimbursement amounts before the export decision, the firm will only export to $S$, for $\mu < \bar{\mu}$ or $\gamma_N > \gamma^*_N$. For $\mu \lesssim \bar{\mu}$ and $\gamma_N < \gamma^*_N$, regulation in $N$ is less strict, the firm’s profit is higher and welfare is

\[ r_N^{\text{PT;RR}} > r_N^{\text{PT;NC}} \quad \text{if} \quad \gamma_N < \gamma^*_N = \frac{(2\mu+3)(2\mu-1)}{18\mu+6\mu^2+3}\]  

with $\gamma^*_N > \gamma_N$.

\[ \gamma_{\text{NS2}} = \frac{(\mu+1)(4\mu+4\mu^2+1)}{(2\mu+1)(18\mu+6\mu^2+3)} \]  

$^22$ \[ \gamma_{\text{NS2}} = \frac{(\mu+1)(4\mu+4\mu^2+1)}{(2\mu+1)(18\mu+6\mu^2+3)} \]  

$^23$ \[ \gamma_{\text{NS2}} = \frac{(\mu+1)(4\mu+4\mu^2+1)}{(2\mu+1)(18\mu+6\mu^2+3)} \]  

$^24$ \[ \gamma_{\text{NS2}} = \frac{(\mu+1)(4\mu+4\mu^2+1)}{(2\mu+1)(18\mu+6\mu^2+3)} \]  

$^25$ \[ \gamma_{\text{NS2}} = \frac{(\mu+1)(4\mu+4\mu^2+1)}{(2\mu+1)(18\mu+6\mu^2+3)} \]  

$^26$ \[ \gamma_{\text{NS2}} = \frac{(\mu+1)(4\mu+4\mu^2+1)}{(2\mu+1)(18\mu+6\mu^2+3)} \]  

$^27$ \[ \gamma_{\text{NS2}} = \frac{(\mu+1)(4\mu+4\mu^2+1)}{(2\mu+1)(18\mu+6\mu^2+3)} \]  

$^28$ \[ \gamma_{\text{NS2}} = \frac{(\mu+1)(4\mu+4\mu^2+1)}{(2\mu+1)(18\mu+6\mu^2+3)} \]  

$^29$ \[ \gamma_{\text{NS2}} = \frac{(\mu+1)(4\mu+4\mu^2+1)}{(2\mu+1)(18\mu+6\mu^2+3)} \]  

$^30$ \[ \gamma_{\text{NS2}} = \frac{(\mu+1)(4\mu+4\mu^2+1)}{(2\mu+1)(18\mu+6\mu^2+3)} \]
lower under no commitment. For $\mu \geq \bar{\mu}$ and $\gamma_N > \gamma_N^{***}$, regulation in $N$ is more strict, the firm’s profit is lower and welfare is higher under no commitment.

7 Price Caps

Consider now regulation via price caps instead of reimbursement limits. Whereas reimbursement limits allow free price setting, price caps are maximum prices. Under parallel trade, a price cap in one country becomes the global price cap. If both countries set price caps, the lower price cap becomes the global price cap, leaving the other price cap non-binding.

7.1 The Effect of Regulation on the Export Decision

Market outcomes under no regulation are equivalent to those in section 3.1.

If parallel trade is allowed and only the South sets a price cap, the firm’s profit is given as

$$\pi_{N,S}^{PT,P} = \frac{1}{\mu} (\mu - (\gamma_N P_S)) P_S + (1 - (\gamma_S P_S)) P_S. \tag{32}$$

The firm exports to the South under parallel trade ($\Delta^P = \pi_{N,S}^{PT,P} - \pi_N > 0$), if $P_S > \frac{4\mu\gamma_N - 2\mu\sqrt{\gamma_N(3\gamma_N - \mu\gamma_S)}}{4\gamma_N(\gamma_N + \mu\gamma_S)}$, i.e. the price cap is sufficiently high and accordingly, regulation is sufficiently flexible in the South.

If parallel trade is allowed and both countries set price caps, the lower price cap becomes the global price cap. The firm’s profit is given as

$$\pi_{N,S}^{PT,P} = \left( \frac{1}{\mu} (\mu - (\gamma_N P)) + (1 - (\gamma_S N P)) \right) P, \tag{33}$$

with $P = \min\{P_N, P_S\}$. If $P = P_N$, the firm (always) sells in the South ($\Delta^{PP} = \pi_{N,S}^{PT,P} - \pi_N > 0$). If $P = P_S$, the firm sells in the South ($\Delta^{PP} = \pi_{N,S}^{PT,P} - \pi_N > 0$), if $P_S > \frac{\mu - \sqrt{\mu^2 - P_N(\mu - \gamma_N P_N)(\gamma_N + \mu\gamma_S)}}{\gamma_N + \mu\gamma_S}$, i.e. the price cap is sufficiently high and accordingly, regulation is sufficiently soft in the South.

7.2 The Effect of Parallel Trade on Regulation

Consider now that governments set price caps to maximize national welfare.
Under no parallel trade, the government in the North maximizes the sum of consumer surplus and the firm’s profit less public pharmaceutical expenditure:

$$W^R_N = CS^P_N - E^P_N + \pi^P = \left(\frac{\mu^2 - \gamma^2_N P^2_N}{2\mu}\right) + P_S \left(1 - \gamma_S P_S\right).$$  \hspace{1cm} (34)

As welfare decreases with the price cap, the government sets:

$$P_N = 0^{24}.$$ \hspace{1cm} (35)

Welfare in the South is given as consumer surplus less public expenditure:

$$W^P_S = CS^P_S - E^P_S = \frac{(1 - \gamma_S P_S) (1 - P_S (2 - \gamma_S))}{2}. \hspace{1cm} (36)$$

As welfare decreases with the price cap, the government sets:

$$P_S = 0.$$ \hspace{1cm} (38)

Price caps of zero imply that consumers may receive the drug free of charge. In this case, every consumer would demand the drug.

Under parallel trade and regulation only in the South, welfare in the South is the same as under no parallel trade (36). If $\mu \leq \mu^{25}$, the government sets

$$P^{PT,P}_S \big|_{\mu \leq \mu^*} = 0,$$ \hspace{1cm} (39)

for $\mu > \mu^*$, the government sets

$$P^{PT,P}_S \big|_{\mu > \mu^*} = \frac{4\mu \gamma_N - 2\mu \sqrt{\gamma_N (3\gamma_N - \mu \gamma_S)}}{4\gamma_N (\gamma_N + \mu \gamma_S)}.$$ \hspace{1cm} (40)

This is, if the market size in the North is sufficiently large, parallel trade relaxes regulation in the South.

If parallel trade is allowed and both countries set price caps, the lower price cap becomes the global price cap. There are two equilibria, one with

$$P = P^{PT,PP}_N = \frac{\mu}{\gamma_N + 2\mu \gamma_S},$$

Note that as the firm has no marginal cost, it is active as long as $P \geq 0$.

$^{25}\mu^* = 2\gamma_N \left(\sqrt{(1 - \gamma_S)(3 - \gamma_S)} - \gamma_S + 2\right)$. 

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one with $P = P_{S}^{PT,PP} = 0$. Welfare in the North is higher under $P = P_{N}^{PT,PP} = \frac{\mu}{\gamma_{N} + 2\mu\gamma_{S}}$, welfare in the South is higher under $P = P_{S}^{PT,PP} = 0$ ($W_{N}^{PP} (P = 0) < W_{S}^{PP} (P = 0)$).

In the North, parallel trade may strengthen regulation under reimbursement limits (if the coinsurance rate is sufficiently low) and may relax regulation under price caps. So, under both instruments, the impact of parallel trade on the regulatory decision in the North may be different.

In the South, parallel trade may relax regulation under both reimbursement limits and price caps, if governments take into account the export decision of the firm. But the effect of more relaxed regulation is different under the two instruments: Under reimbursement limits, more relaxed regulation implies higher reimbursement amounts and lower copayments (i.e. a shift of the financing burden from the patient to the insurer); under price caps, more relaxed regulation results in higher price caps, that is, higher copayments and higher reimbursement (i.e. an increase in the transfer from patient and insurer to the firm). This is, although parallel trade relaxes regulation under both instruments, market outcomes differ.

Proposition 5 summarizes the effect of price caps.

**Proposition 5** If both governments set price caps, parallel trade may relax regulation in both countries.

### 8 Conclusion

In this paper, I have studied the interaction of pharmaceutical regulation and parallel trade in a North-South framework. An innovative firm located in the North can sell its drug only in the North or in both countries. Governments may limit reimbursement for the drug.

Under parallel trade, the firm may refuse to the supply the South. Reimbursement limits may further limit the incentive to supply the South. This is, national regulation plays an important role for the consequences of parallel trade.

As parallel trade changes prices, regulation may also respond to parallel trade. The model suggests that parallel trade may increase the strictness of regulation in the North, while having no effect on the regulation decision in the South, if the market size of the North is sufficiently small and relax regulation in the South otherwise.
References


Appendix

The Effect of Regulation on the Export Decision

No Regulation
\[
\Delta = \pi_{N,S}^P - \pi_N = \mu \frac{3\gamma_N - \mu\gamma_N}{4\gamma_N(\gamma_N + \mu \gamma_N)} > 0,
\]
if \( \mu < \frac{3\gamma_N}{\gamma_N} \).

Regulation
\[
\Delta R = \pi_{N,S}^P - \pi_N = \mu \frac{3\gamma_N - \mu + \gamma_N r_{S}^{PT,R}(1 - \gamma_N)(4 + r_{S}^{PT,R}(1 - \gamma_N))}{4\gamma_N(\gamma_N + \mu + \gamma_N)} > 0,
\]
if \( \mu < 3\gamma_N + \gamma_N r_{S}^{PT,R}(1 - \gamma_N)(4 + r_{S}^{PT,R}(1 - \gamma_N)) \)
\[
\vee r_{S}^{PT,R} \geq \frac{\sqrt{\gamma_N(\mu + \gamma_N) - 2\gamma_N}}{\gamma_N(1 - \gamma_N)}.
\]

Under the assumption that \( r_{N} = r_{N}^{PT,RR} \):
\[
\Delta R_{RR} = \pi_{N,S}^{PT,RR} - \pi_N = \mu \frac{3(\gamma_N - \mu + \gamma_N r_{S}^{PT,RR}(1 - \gamma_N)(4 + r_{S}^{PT,RR}(1 - \gamma_N)) + 2(\mu - 1))}{4(\mu + 1)}
\]
+ \( \frac{\mu r_{S}^{PT,RR}(1 - \gamma_N)(4 + r_{S}^{PT,RR}(1 - \gamma_N))}{4(\mu + 1)} > 0, \)
if \( \mu < \mu^* = \frac{1}{2} r_{S}^{PT,RR}(1 - \gamma_N)(4 + r_{S}^{PT,RR}(1 - \gamma_N)) - r_{N}^{PT,RR}(1 - \gamma_N) \)
\[
+ \frac{3}{2} \sqrt{r_{S}^{PT,RR}(1 - \gamma_N)(6 + r_{S}^{PT,RR}(1 - \gamma_N)) - 4r_{N}^{PT,RR}(1 - \gamma_N)} + 9(1 + r_{S}^{PT,RR}(1 - \gamma_N)) \]
\[
\vee r_{S}^{PT,RR} > r_{S}^{PT,RR^*} = \frac{\sqrt{\mu + 1 + \mu r_{S}^{PT,RR}(1 - \gamma_N) - 2\mu - r_{N}^{PT,RR}(1 - \gamma_N)}}{\mu(1 - \gamma_N)}.
\]

Under the assumption that \( r_{N} \neq r_{N}^{PT,RR} \):
\[
\Delta R_{RR} = \pi_{N,S}^{PT,RR} - \pi_N = \mu \frac{-\mu^2(\mu - 3)(4 + r_{N}^{PT,RR}(1 - \gamma_N)) + \mu r_{S}^{PT,RR}(1 - \gamma_N)(4 + r_{S}^{PT,RR}(1 - \gamma_N))}{4\mu(\mu + 1)}
\]
+ \( \frac{\mu r_{S}^{PT,RR}(1 - \gamma_N)(4 + r_{S}^{PT,RR}(1 - \gamma_N))}{4\mu(\mu + 1)} > 0, \)
if \( r_{S}^{PT,RR} > r_{S}^{PT,RR^*} = \frac{\sqrt{\mu + 1 + \mu r_{S}^{PT,RR}(1 - \gamma_N) - 2\mu - r_{N}^{PT,RR}(1 - \gamma_N)}}{\mu(1 - \gamma_N)} \).

The Effect of Parallel Trade on Regulation
\[
W_S^{PT,R}(r_S = 0) = \frac{\gamma^2}{2(\mu + \gamma_N)^2},
\]
\[
W_S^{PT,R}(r_S^{PT,R} = 0) = 4\sqrt{\gamma_N^2 + \mu \gamma_N(3\mu + 4\gamma_N) - 3\mu^2 - 16\gamma_N^2 - 20\mu \gamma_N}
\]
\[
\Delta R(r_S^{PT,R} = 0) = \frac{\mu(3\gamma_N - \mu)}{4\gamma_N(\mu + \gamma_N)} > 0,
\]
if \( \mu < 3\gamma_N \).
\[
\Delta RR(r_N^{PT,RR} = 0, r_S^{PT,RR} = 0) = \frac{2(\mu + 2)}{(1 - \gamma_N)(\mu + 4\mu^2 + 1)}, r_S^{PT,RR} = 0 = \frac{-16\mu^3 + 56\mu^9 + 32\mu^2}{64\mu^4 + 192\mu^3 + 176\mu^2 + 48\mu + 4} > 0,
\]
if \( \mu \leq 2.25 \).
\[
\Delta_{RR} \left( r_{PT,RR} = \frac{2\mu(\mu+2)}{(1-\gamma N)(6\mu+4\mu^2+1)}, r_S^{PT,RR} = 0, r_N = \frac{\mu}{\gamma N+1} \right) \\
= \frac{\mu(21\mu-4\mu^2-32\mu^3-16\mu^4+8+\gamma N(\mu+1)(4\mu+3)^2(\gamma N+2))}{(\gamma N+1)^2(4\mu^2+6\mu+1)^2} > 0,
\]
if \( \gamma N > \frac{\sqrt{\mu+T(6\mu+4\mu^2+1)} - (\mu+1)(4\mu+3)}{N+4\mu^2+3} \)

\[
\gamma N = 0.05: \tilde{\mu} = 0.88191 \\
\gamma N = 0.1: \tilde{\mu} = 0.97786 \\
\gamma N = 0.15: \tilde{\mu} = 1.079 \\
\gamma N = 0.2: \tilde{\mu} = 1.1855 \\
\gamma N = 0.25: \tilde{\mu} = 1.2972 \\
\gamma N = 0.3: \tilde{\mu} = 1.4143 \\
\gamma N = 0.35: \tilde{\mu} = 1.5369 \\
\gamma N = 0.4: \tilde{\mu} = 1.664 \\
r_{PT,RR}^{PT,RR} \bigg|_{\mu < \tilde{\mu}} - r_N = \mu \frac{\gamma N(8\mu+4\mu^2+5)-4\mu-4\mu^2+3}{(1-\gamma N)(\gamma N+1)(6\mu+4\mu^2+1)} > 0,
\]
if \( \gamma N > \frac{2\mu(3)(2\mu+1)}{8\mu+4\mu^2+5} \)

\[
r_{PT,RR}^{PT,RR} \bigg|_{\mu > \tilde{\mu}} - r_N = 2\mu \frac{(\mu+1)(-2\mu-3+\gamma N(1+2\mu)) + \sqrt{\mu+T(2\mu+3)}}{(1-\gamma N)(\gamma N+1)(4\mu+1)^2 - \sqrt{\mu+T(2\mu+3)}} > 0,
\]
if \( \gamma N > \frac{(2\mu+3)(\sqrt{\mu+T}-1)}{(4\mu+1)\sqrt{\mu+T}} \)

\[
r_S^{PT,RR} \bigg|_{\mu < 3\gamma N} - r_S = \sqrt{\frac{\gamma N(\mu+\gamma N)-2\gamma N}{\gamma N(1-\gamma N)}} > 0 \\
r_S^{PT,RR} \bigg|_{\mu > 3\gamma N} - r_S = 0 \\
r_S^{PT,RR} \bigg|_{\mu < \tilde{\mu}} - r_S = 0 \\
r_S^{PT,RR} \bigg|_{\mu > \tilde{\mu}} - r_S = \frac{\sqrt{\mu+T(8\mu+4\mu^2+5)-8\mu^2-14\mu-6}}{(1-\gamma N)(4\mu+1)^2 - \sqrt{\mu+T(2\mu+3)}} > 0
\]

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\[
\Delta_{RR} \left( r_{PT,RR,C} = \frac{2\mu}{(1-\gamma N)(\mu+1)}, r_S^{PT,RR,C} = \frac{2\mu}{(1-\gamma S)(\mu+1)} \right) \\
= \frac{-\mu^3+10\mu^2+4\mu+4}{4\mu^2+8\mu+4} > 0, \text{if } \mu < 10.657 \\
\Delta_{RR} \left( r_{PT,RR,C}^{PT,RR,C} = \frac{2\mu}{(1-\gamma N)(\mu+1)}, r_S^{PT,RR,C} = \frac{2\mu}{(1-\gamma S)(\mu+1)}, r_N = \frac{\mu}{\gamma N+1} \right) \\
= \frac{\mu(4\gamma N^2+8\gamma N-\mu+3)}{(\mu+1)(\gamma N+1)^2} > 0, \text{if } \mu < \tilde{\mu} = 4\gamma N^2 + 8\gamma N + 3 \\
r_{PT,RR,C}^{PT,RR,C} \bigg|_{\mu \leq 10.657} - r_N = \frac{\mu}{(1-\gamma N)(\mu+1)(6\mu+4\mu^2+1)} > 0 \\
r_{PT,RR,C}^{PT,RR,C} \bigg|_{\mu > 10.657} - r_N = \frac{\mu(10(\mu+1)^2-\sqrt{\mu+T}(\mu+3)(2\mu+3))}{(\mu+1)(1-\gamma N)(4\mu+1)^2 - \sqrt{\mu+T}(2\mu+3)} > 0 \\
r_{PT,RR,C}^{PT,RR,C} \bigg|_{\mu \leq 10.657} - r_S = \frac{2(8\mu+3)(\mu+1)}{(\mu+1)(1-\gamma N)(4\mu+1)^2 - \sqrt{\mu+T}(2\mu+3)} > 0 \\
r_{PT,RR,C}^{PT,RR,C} \bigg|_{\mu > 10.657} - r_S = \frac{2(8\mu+3)(\mu+1)}{(\mu+1)(1-\gamma N)(4\mu+1)^2 - \sqrt{\mu+T}(2\mu+3)} > 0
\]
\[
\begin{align*}
W_{PT,RR} & \left( \begin{array}{c|c|c}
R_{PT,RR} & R_{PT,RR} & R_{PT,RR} \\
\mu < \mu & \mu < \mu & \mu < \mu \\
R_{PT,RR} & R_{PT,RR} & R_{PT,RR} \\
\mu < \mu & \mu < \mu & \mu < \mu \\
R_{PT,RR} & R_{PT,RR} & R_{PT,RR} \\
\mu < \mu & \mu < \mu & \mu < \mu \\
\end{array} \right) = \frac{2 \mu (4(\mu + 1)^2 - 2(\mu + 1) - 115 - 85\mu^2 - 6\mu^3 - 4\mu^4 - 52)}{2(\mu + 1)(8\mu + 4\mu^2 + 4 - \sqrt{\mu + T(2\mu + 3)})^2} > 0 \\
W_{PT,RR} & \left( \begin{array}{c|c|c}
R_{PT,RR} & R_{PT,RR} & R_{PT,RR} \\
\mu < \mu & \mu < \mu & \mu < \mu \\
R_{PT,RR} & R_{PT,RR} & R_{PT,RR} \\
\mu > \mu & \mu > \mu & \mu > \mu \\
R_{PT,RR} & R_{PT,RR} & R_{PT,RR} \\
\mu > \mu & \mu > \mu & \mu > \mu \\
\end{array} \right) = \frac{4(\mu + 1)(18\mu + 22\mu^2 + 12\mu^3 + 15) - 167\mu - 213\mu^2 - 155\mu^3 - 64\mu^4 - 12\mu^5 - 61}{2(\mu + 1)(4(\mu + 1)(8\mu + 4\mu^2 + 5) - 8\sqrt{\mu + T(2\mu + 3)})(\mu + 1))} < 0 \\
W_{PT,RR} & \left( \begin{array}{c|c|c}
R_{PT,RR} & R_{PT,RR} & R_{PT,RR} \\
\mu < \mu & \mu < \mu & \mu < \mu \\
R_{PT,RR} & R_{PT,RR} & R_{PT,RR} \\
\mu > \mu & \mu > \mu & \mu > \mu \\
R_{PT,RR} & R_{PT,RR} & R_{PT,RR} \\
\mu > \mu & \mu > \mu & \mu > \mu \\
\end{array} \right) = \frac{4(\mu + 1)(611\mu + 546\mu^2 + 200\mu^3 + 16\mu^4 + 251)(\mu + 1)^2}{2(\mu + 1)(8\mu + 4\mu^2 + 4 - \sqrt{\mu + T(2\mu + 3)})^2} > 0 \\
W_{PT,RR} & \left( \begin{array}{c|c|c}
R_{PT,RR} & R_{PT,RR} & R_{PT,RR} \\
\mu > \mu & \mu > \mu & \mu > \mu \\
R_{PT,RR} & R_{PT,RR} & R_{PT,RR} \\
\mu > \mu & \mu > \mu & \mu > \mu \\
R_{PT,RR} & R_{PT,RR} & R_{PT,RR} \\
\mu > \mu & \mu > \mu & \mu > \mu \\
\end{array} \right) = \frac{4(\mu + 1)(3960\mu + 626\mu^2 + 4978\mu^3 + 1980\mu^4 + 312\mu^5 + 1005)(\mu + 1)^2}{2(\mu + 1)(8\mu + 4\mu^2 + 4 - \sqrt{\mu + T(2\mu + 3)})^2} > 0 \\
\end{align*}
\]
\[- \frac{4 \sqrt{\mu + T} \left(1575 \mu + 2196 \mu^2 + 1448 \mu^3 + 429 \mu^4 + 24 \mu^5 + 441\right) (\mu + 1)^2}{2(\mu + 1)^2 \left(4(\mu + 1) - 3 \sqrt{\mu + T}\right)^2 \left(4(\mu + 1) - 3 \sqrt{\mu + T}\right)^2 (\mu + 1)^2} < 0\]

No Commitment

\[\pi^E - \pi^{NE} = \mu \left(21 \mu - 4 \mu^2 - 32 \mu^3 - 16 \mu^4 + 8 + \gamma_N(\mu + 1)(4 \mu + 3)^2 (\gamma_N + 2)\right) \frac{(\gamma_N + 1)^2 (\mu^2 + 4 \mu^2 + 1)^2}{(\mu + 1)(4 \mu + 3)} \]

if \(\gamma_N > \gamma^* \) \(= \frac{\sqrt{\mu + T} (6 \mu + 4 \mu^2 + 1) - (\mu + 1)(4 \mu + 3)(\mu - 1)}{(1 - \gamma^*) (4 \mu + 3)(\mu + 1)(6 \mu + 4 \mu^2 + 1)} > 0\)

if \(\gamma_N > \gamma^{**} \) \(= \frac{\gamma_N (8 \mu + 4 \mu^2 + 5) - (2 \mu + 3)(2 \mu - 1)}{(1 - \gamma_N)(\mu + 1)(6 \mu + 4 \mu^2 + 1)} > 0\)

if \(\gamma_N > \gamma^{***} \) \(= \frac{(6 \mu + 4 \mu^2 + 1)(2 \mu + 1)(4 \mu + 3) - \sqrt{\mu + T} (8 \mu + 4 \mu^2 + 5)}{(1 - \gamma_N)(4 \mu + 3)(\mu + 1)(6 \mu + 4 \mu^2 + 1)} > 0\)

if \(\gamma_N > \gamma^{****} \) \(= \frac{\mu (\mu + 1)(6 \mu + 5 + \gamma_N(2 \mu + 1) - \sqrt{\mu + T}(2 \mu + 3)) (\mu + 1)(2 \mu - 1)}{(1 - \gamma_N)(4 \mu + 3)(\mu + 1)(6 \mu + 4 \mu^2 + 1)} > 0\)

if \(\gamma_N < \gamma^{*****} \) \(= \frac{\mu ((\mu + 1)(4 \mu + 4 \mu^2 - 1)(-2 \sqrt{\mu + T} + 1))}{2(\mu + 1)(18 \mu + 6 \mu^2 + 13)} > 0\)

if \(\mu > 2.6\)

23
Price Caps

\[
\Delta^P = \pi_{P,TT}^P - \pi_N = \frac{1}{3} \gamma_N P_S (2 \mu + \gamma_N P_S + \mu^2 P_S) - \mu^2
\]

\[
\Delta^{PP} = \pi_{P,TT}^{P,PP} - \pi_N = P (1 - P \gamma_S) > 0
\]

\[
\Delta^P|_{P=S} = \pi_{P,TT}^P - \pi_N = \frac{\mu (1 - P \gamma_S) + (P_N - P) (-\mu + \gamma_N (P + P_N))}{\mu}
\]

\[
\Delta^P|_{P=S=0} = 4 \gamma_N (2 \mu - \gamma_N - \mu^2) - \mu^2 > 0
\]

if \( \mu < 2 \gamma_N \left( \sqrt{(1 - \gamma_S)(3 - \gamma_S)} - \gamma_S + 2 \right) \)

Candidate 1

For \( P = P_N \leq P_S \), welfare in the North is given as

\[
W_{P,TT}^N = C_{P,TT}^N - E_{P,TT}^N + \pi_N = \frac{\mu^2 + P_{P,TT}^{P,PP} (2 \mu - P_{P,TT}^{P,PP} (\gamma_N + 2 \mu \gamma_S))}{2 \mu}
\]

and the government sets \( P_{P,TT}^{P,PP} = \frac{\mu}{\gamma_N + 2 \mu \gamma_S} \). The government in the South sets \( P_S = P_N = P \), the lowest price compatible with the equilibrium.

Candidate 2

For \( P = P_S \leq P_N \), welfare in the South is the same as under no parallel trade (36) and the government sets \( P_{P,TT}^{P,PP} = \frac{\mu - \sqrt{\mu^2 - P_N (\mu - \gamma_N P_N)(\gamma_N + \mu \gamma_S)}}{\gamma_N + \mu \gamma_S} \), the lowest price compatible with the firm exporting. \( P_N \) here is the price cap in the North, if the firm does not export, \( P_N = 0 \). This is, the government in the South would set \( P_{P,TT}^{P,PP} = 0 \).

The government in the North sets \( P_N = P_S = P \), the lowest price compatible with the equilibrium.

\[
W_{P,TT}^N \left( P = P_{P,TT}^{P,PP} = \frac{\mu}{\gamma_N + 2 \mu \gamma_S} \right) = \frac{\mu (\gamma_N^2 + 2 \mu \gamma_S + 1)}{2 \gamma_N^2 + 4 \mu \gamma_S}
\]

\[
W_{P,TT}^S \left( P = P_N = \frac{\mu}{\gamma_N + 2 \mu \gamma_S} \right) = \frac{(\gamma_N^2 + \mu \gamma_S)(-2 \mu + \gamma_N^2 + 3 \mu \gamma_S)}{2(\gamma_N^2 + 2 \mu \gamma_S)^2}
\]

\[
W_{P,TT}^N \left( P = P_{P,TT}^{P,PP} = 0 \right) = \frac{1}{2} \mu
\]

\[
W_{P,TT}^S \left( P = P_{P,TT}^{P,PP} = 0 \right) = \frac{1}{2}
\]

\[
W_{P,TT}^N \left( P = P_{P,TT}^{P,PP} = 0 \right) - W_{P,TT}^N \left( P = P_{P,TT}^{P,PP} = \frac{\mu}{\gamma_N + 2 \mu \gamma_S} \right) = -\frac{1}{2} \frac{\mu^2}{\gamma_N + 2 \mu \gamma_S} < 0
\]

\[
W_{P,TT}^S \left( P = P_{P,TT}^{P,PP} = 0 \right) - W_{P,TT}^S \left( P = P_N = \frac{\mu}{\gamma_N + 2 \mu \gamma_S} \right) = \frac{1}{2} \frac{\mu (2 \gamma_N^2 + \mu \gamma_S^2 + 2 \mu \gamma_S)}{(\gamma_N^2 + 2 \mu \gamma_S)} > 0
\]

\[26\] If the firm does not export, welfare in the North is given as \( W_P^N = C_{P}^N - E_P^N + \pi_P = \frac{(\mu^2 - \gamma_N^2 P_N^2)}{2 \mu} \).