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Externalities of Wholesale Level Regulation under Pharmaceutical Parallel Trade

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Abstract

This paper studies the effect of pharmaceutical regulation at the wholesale level under parallel trade, i.e. trade outside the manufacturer's authorized distribution channel. In a symmetric equilibrium, both maximum wholesale margins (restriction of pricing by the intermediary) and manufacturer discounts (restriction of the pricing by the manufacturer) decrease the drug price in the respective country. Instruments differ in their effect on the other country: Whereas maximum wholesale margins increase the drug price in the other country, manufacturer discounts may decrease it.

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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). The profitability of parallel trade in pharmaceuticals depends on substantial cross-country price differences, which may result from manufacturers' price discrimination, divergent wholesale prices and/or cross-country differences in regulation.

Countries usually regulate drug prices in order increase (national) welfare. The interdependency of parallel trade and regulation is particularly relevant, as it touches upon the conflict between nationally determined health policy and market integration via parallel trade.

The EU provides for national competence of member states in health policy, including pharmaceutical regulation. At the same time, parallel trade results in market integration. Externalities may emerge, whereby regulatory decisions in one country have an effect on other countries as well. Birg (2015) shows that changes in the coinsurance rate in one country may magnify or mitigate the effects of parallel trade in both destination and source country of parallel imports.

The previous literature on parallel trade and regulation has mainly focused on retail price regulation, suggesting that parallel trade may distort policy choices towards lower (Rey, 2003) or higher price caps (Pecorino, 2002, Grossman & Lai, 2008).

This paper explores cross-country externalities of wholesale level regulation, namely maximum wholesale margins (restriction of pricing by the intermediary) and manufacturers discounts (restriction of the pricing by the manufacturer). I consider a two-country model with a manufacturer selling through independent intermediaries following Ganslandt & Maskus (2007). A vertical price control model is an adequate framework because pharmaceutical manufacturers typically do not sell directly but through independent wholesalers (Taylor, Mrazek & Mossialos, 2004).

The manufacturer responds to parallel trade by raising wholesale prices to reduce competition, thereby creating a double marginalization effect. The first best solution would be to stimulate competition or to enforce vertical integration, which is inhibited by patent protection (manufacturer level) or large cost of entry and economies of scale (retail level) or prohibited by national regulation (Taylor; Mrazek & Mossialos, 2004). Instead, regulatory instruments restrain pricing, either for the intermediary or the manufacturer. Maximum wholesale margins may be inappropriate when market are integrated by parallel trade because they reduce prices where applied but increase prices in other countries. Manufacturer discounts may be more appropriate for integrated markets. They result in no spillovers or even reduce drug prices also in the other country.

The paper is organized as follows. Section 2 presents the model, section 3-5 analyze the equilibria without regulation, with maximum wholesale margins, and manufacturer discounts. Section 6 concludes.

2. The Model

A manufacturer M sells a brand-name drug b in two countries ($j = D, S$), in each through an independent intermediary I_j[1]. Assume that I_S resells the drug b in D as a parallel import (hereafter noted as β) (one-way parallel trade, which is consistent with

[1] The model set-up follows Ganslandt & Maskus (2007) but considers price competition with differentiated products. Birg (2015) uses a similar set-up but considers direct sales of the manufacturer in the destination country as in Maskus & Chen (2002), (2004) and Chen & Maskus (2005).

empirical evidence). S is the source country, D is the destination country of parallel trade.

Consider a two-stage game: In the first stage, the manufacturer charges each intermediary a wholesale price w_j per unit and a fixed fee ϕ_j (two-part tariff). In the second stage, intermediaries compete in prices.

Consumers are heterogeneous in their valuation θ, which is uniformly distributed on the interval $[0,1]$. Heterogeneity may stem from differences in income, the severity of the condition or prescription practices (see e.g. Brekke, Holmas & Straume, 2011). The total mass of consumers is 1 in both countries.

Consumers attribute a lower quality to the parallel import due to differences in appearance and packaging or an interpretation of a lower price as a quality indicator (Maskus, 2000; Waber et al., 2008). This is modeled as a discount factor in valuation $\tau \in (0,1)$. Consumers pay a fraction γ_j of the drug price (coinsurance).

Let

$$U(\theta,\tau,\gamma_j,p_i) = \begin{cases} \theta - \gamma_j p_{i,j} & \text{if } i = b \\ \theta(1-\tau) - \gamma_j p_{i,j}, & \text{if } i = \beta \end{cases} \tag{1}$$

be the utility of a consumer who buys one unit of drug i $(i = b, \beta)$, where $p_{i,j}$ is the price of drug i in country j.

Assume that the dispersion of coinsurance rates across both markets is sufficiently low, $\gamma_S \leq \frac{4\gamma_D}{(1-\tau)}$, so that the manufacturer serves both markets in equilibrium.

In D, demand for b and β is

$$q_{b,D} = 1 - \frac{\gamma_D(p_{b,D} - p_{\beta,D})}{\tau} \text{ and } q_{\beta,D} = \frac{\gamma_D(p_{b,D} - p_{\beta,D})}{\tau} - \frac{\gamma_D p_{\beta,D}}{(1-\tau)}. \tag{2}$$

In S, demand for b is

$$q_{b,S} = 1 - \gamma_S p_{b,S}. \tag{3}$$

Marginal costs of production and trade cost are constant and normalized to zero. Profits are

$$\begin{aligned} \pi_M &= w_D q_{b,D} + w_S q_{b,S} + w_S q_{\beta,D} + \phi_D + \phi_S, \\ \pi_{I_D} &= (p_{b,D} - w_D)\, q_{b,D} - \phi_D, \\ \pi_{I_S} &= (p_{b,S} - w_S)\, q_{b,S} + (p_{\beta,D} - w_S)\, q_{\beta,D} - \phi_S. \end{aligned} \tag{4}$$

3. Equilibrium without Regulation

Equilibrium wholesale and retail prices as well as quantities can be found in Table 1.

D	S
$w_D = \frac{2(1-\tau)(\gamma_D+\tau\gamma_S(1-\tau))}{\gamma_D(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$	$w_S = \frac{2(1-\tau)}{4\gamma_D+\gamma_S(3\tau+1)(1-\tau)}$
$p_{b,D} = \frac{2(\gamma_D+\tau\gamma_S(1-\tau))}{\gamma_D(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$	$p_{b,S} = \frac{4\gamma_D+3\gamma_S(1-\tau^2)}{2\gamma_S(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$
$p_{\beta,D} = \frac{(1-\tau)(2\gamma_D+\tau\gamma_S(1-\tau))}{\gamma_D(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$	
$q_{b,D} = \frac{2(\gamma_D+\tau\gamma_S(1-\tau))}{4\gamma_D+\gamma_S(3\tau+1)(1-\tau)}$	$q_{b,S} = \frac{4\gamma_D-\gamma_S(1-3\tau)(1-\tau)}{2(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$
$q_{\beta,D} = \frac{(1-\tau)\gamma_S}{4\gamma_D+\gamma_S(3\tau+1)(1-\tau)}$	

Table 1: Equilibrium without Regulation

The manufacturer cannot block parallel trade, but is provided with the possibility to exploit the intermediaries' market power: By raising w_D and w_S, the manufacturer can enforce a coordinated price increase and reduce competition from parallel trade. This strategic effect is stronger when products are close substitutes (low τ). At the same time, the associated increase in $p_{b,S}$ and decrease in $q_{b,S}$ following the increase in the wholesale price (double marginalization effect) limit this effect. For a high price elasticity, resp. high coinsurance rate in S, a given price increase reduces quantity more.

Parallel trade makes the manufacturer raise wholesale prices to reduce competition, thereby creating a double marginalization effect in both countries. If the manufacturer reduced the quantity supplied to the intermediary in country S, the effect on prices and quantities in both countries would be equivalent to increasing the wholesale price for I_S. Note that it is not optimal for the manufacturer to block parallel trade completely by increasing the wholesale price or reducing the quantity sufficiently.

4. Maximum Wholesale Margins

Under maximum wholesale margins, intermediaries' price-setting is restricted to $p^{\mu}_{i,j} = w^{\mu}_j + m_j$, with $m_j < p_{i,j} - w_j$. To illustrate the effect of maximum wholesale margins, I first explore the special case of one country enforcing marginal cost pricing ($m_j = 0$, see Appendix, Tables 2 and 3), then I describe the symmetric equilibrium of both countries applying maximum wholesale margins (see Appendix, Table 4).

If marginal cost pricing is applied in D, it cuts the link between w^{μ}_D (w^{μ}_S) and $p^{\mu}_{\beta,D}$ ($p^{\mu}_{b,D}$) and an increase of w^{μ}_D (w^{μ}_S) does not raise $p^{\mu}_{\beta,D}$ ($p^{\mu}_{b,D}$). But as an increase in wholesale prices translates to **a** one-to-one increase in retail prices, the manufacturer can reduce competition from parallel trade to a larger extent. This increase in w^{μ}_D and w^{μ}_S is again limited by the double marginalization effect in S. In D, marginal cost pricing and the increase in w^{μ}_D and w^{μ}_S reduce $p^{\mu}_{b,D}$, but increase $p^{\mu}_{\beta,D}$ if price elasticity in S is sufficiently low, reducing the relative price $p^{\mu}_{b,D}/p^{\mu}_{\beta,D}$ and shifting demand from β to b. In S, the increase in w^{μ}_S aggravates the double marginalization effect, increasing $p^{\mu}_{b,S}$ and reducing $q^{\mu}_{b,S}$.

If marginal cost pricing is applied in S, it resolves the double marginalization effect and allows the manufacturer to increase both wholesale prices more and to reduce competition from parallel trade to a greater extent. In D, the increase in wholesale prices raises both drug prices, reducing the relative price $p^{\mu}_{b,D}/p^{\mu}_{\beta,D}$ and shifting demand from β to b. For a low coinsurance rate in S the manufacturer may block parallel trade. In S, without the double marginalization effect, $p^{\mu}_{b,S}$ is lower and $q^{\mu}_{b,S}$ is higher.

Regardless of which country applies maximum wholesale margins, cross-country externalities occur: The adoption of maximum wholesale margins in D aggravates the double marginalization effect in S, the adoption of maximum wholesale margins in S reduces competition from parallel trade in D.

Both countries applying maximum wholesale margins induces the manufacturer to increase wholesale prices even more: First, maximum wholesale margins in S mitigate the double marginalization effect in S, which prevented further increases in the first special case. Second, maximum wholesale margins in D increase the impact of wholesale price increases, as intermediaries pass them on to retail prices completely, which makes further price increases more attractive than in the second special case. This effect is stronger, the stricter regulation is (lower m_j). Thus, wholesale prices decrease in m_D and m_S, as wholesale prices are strategic complements.

In D, drug prices increase in m_D (via restriction of intermediaries' markups and the wholesale price) and decrease in m_S (via the wholesale price), in S vice versa. The effect on competition from parallel trade is ambiguous; it depends on the relative price $p^{\mu}_{b,D}/p^{\mu}_{\beta,D}$.

If both countries set m_j to reduce drug prices, in equilibrium they set $m_D = m_S = 0$. For $\widehat{\gamma_{D,S}} < \gamma_D < \widehat{\gamma_{D,H}}$, drug prices in this equilibrium are lower than under no regulation, but for $\gamma_D < \widehat{\gamma_{D,S}}$, the price in D is higher than without regulation ($p^{\mu}_{b,D} > p_{b,D}$, $p^{\mu}_{b,S} < p_{b,S}$) and for $\gamma_D > \widehat{\gamma_{D,H}}$, the price in S is higher than without regulation ($p^{\mu}_{b,D} < p_{b,D}$, $p^{\mu}_{b,S} > p_{b,S}$). This result holds for all equilibria with $m_D = m_S$.

If under parallel trade, one country applies maximum wholesale margins to decrease drug prices, it decreases the drug price in the respective country but increases the price in the other country. This creates the incentive for the other country also to apply maximum wholesale margins to decrease the drug price again. Each country may end up in an equilibrium where drug prices are higher than without regulation.

5. Manufacturer Discounts

Under manufacturer discounts, the manufacturer's price-setting is restricted to $w^{\psi}_j = w_j\psi_j$, with $\psi_j \in [0, 1)$. Manufacturer discounts are combined with wholesale price freezes to prevent strategic price increases. To illustrate the effect of manufacturer discounts, I first explore the special case of one country enforcing marginal cost pricing ($\psi_j = 0$, see Appendix, Tables 5 and 6), then I describe the symmetric equilibrium of both countries applying maximum wholesale margins (see Appendix, Table 7).

If marginal cost pricing is applied in D, it allows the manufacturer to reduce competition from parallel trade more effectively via w^{ψ}_S, as $\frac{\partial p^{\psi}_{\beta,D}}{\partial w^{\psi}_S} > \frac{\partial p^{\psi}_{b,D}}{\partial w^{\psi}_S}$. Competition is less important relative to the double marginalization problem in S and he decreases w^{ψ}_S. In D, lower wholesale prices decrease $p^{\psi}_{b,D}$ and $p^{\psi}_{\beta,D}$, decreasing the relative price $p^{\psi}_{b,D}/p^{\psi}_{\beta,D}$ and shifting demand from the parallel import to the locally sourced version. For a low coinsurance rate in S the manufacturer may block parallel trade. In S, the decrease of the wholesale price w^{ψ}_S mitigates the double marginalization problem, decreasing $p^{\psi}_{b,S}$ and increasing $q^{\psi}_{b,S}$.

If marginal cost pricing is applied in S, a wholesale price w^{ψ}_S of zero intensifies competition from parallel trade in D. The manufacturer decreases w^{ψ}_D to promote sales of b. In D, lower wholesale prices decrease $p^{\psi}_{b,D}$ and $p^{\psi}_{\beta,D}$, increasing the relative price $p^{\psi}_{b,D}/p^{\psi}_{\beta,D}$ and shifting demand from b to β. In S, manufacturer discounts mitigate the double marginalization effect, reducing $p^{\psi}_{b,S}$ and increasing $q^{\psi}_{b,S}$.

Regardless of which country applies manufacturer discounts, externalities occur: The adoption of manufacturer discounts in D mitigates the double marginalization effect in S, the adoption of manufacturer discounts in S stimulates competition from parallel trade in D.

Both countries applying manufacturer discounts prevents a strategic response by the manufacturer to regulation via wholesale prices and accordingly externalities at the wholesale level. In D, drug prices are lower, as both drug prices depend positively on both wholesale prices, ψ_D and ψ_S are strategic complements. Which country sets the lower wholesale price determines the relative price $\frac{p^{\psi}_{b,D}}{p^{\psi}_{\beta,D}}$ and thus competition from parallel trade ($\frac{\partial p^{\psi}_{b,D}}{\partial w^{\psi}_D} > \frac{\partial p^{\psi}_{\beta,D}}{\partial w^{\psi}_D}$, $\frac{\partial p^{\psi}_{\beta,D}}{\partial w^{\psi}_S} > \frac{\partial p^{\psi}_{b,D}}{\partial w^{\psi}_S}$). In S, $p^{\psi}_{b,S}$ is lower, because w_S is.

If both countries set ψ_j to reduce drug prices, in equilibrium they set $\psi_D = \psi_S = 0$, yielding lower drug prices in both countries.

If under parallel trade, D applies manufacturer discounts, it decreases prices in D and S; if S applies manufacturer discounts, it decreases the drug price in S. Other than maximum wholesale margins, manufacturer discounts generate no unintended price increases in the respective other country.

6. Conclusion

Externalities of wholesale level regulation may not be avoided. The choice of regulatory instruments determines the type of externalities. Commonly applied maximum wholesale margins may be inappropriate when markets are integrated by parallel trade. They reduce drug prices where applied but increase drug prices in other countries. In a symmetric equilibrium, in one country, drug prices may be higher than without regulation.

Manufacturer discounts may be a more appropriate alternative. They reduce drug prices also in countries other than where applied or result in no spillovers. Other than maximum wholesale margins, manufacturer discounts generate no unintended price increases in the respective other country.

These results suggest that under parallel trade coordination between EU member states could prevent unintended price increases. If countries apply manufacturer discounts instead of maximum wholesale margins, there are no unintended prices increases. Alternatively, if countries set coinsurance rates cooperatively, they may avoid an equilibrium with higher drug prices for one country under maximum wholesale margins. However, coinsurance rates are usually set in accordance with various health policy objectives, including distributive objectives.

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Appendix

D	S
$w_D^\mu = \frac{4\gamma_D+\tau\gamma_S(1-\tau)}{2\gamma_D(4\gamma_D+\gamma_S(1-\tau))}$ $w_D^\mu - w_D = \frac{\tau\left(16\gamma_D^2+4\gamma_S\gamma_D(4\tau+1)(1-\tau)+\gamma_S^2(7\tau-3)(1-\tau)^2\right)}{2\gamma_D(4\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0$	$w_S^\mu = \frac{2(1-\tau)}{(4\gamma_D+\gamma_S(1-\tau))}$ $w_S^\mu - w_S = \frac{6\tau\gamma_S(1-\tau)^2}{(4\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0$
$p_{b,D}^\mu = \frac{4\gamma_D+\tau\gamma_S(1-\tau)}{2\gamma_D(4\gamma_D+\gamma_S(1-\tau))}$ $p_{b,D}^\mu - p_{b,D} = -\frac{3\tau\gamma_S^2(1-\tau)^3}{2\gamma_D(4\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} < 0$	$p_{b,S}^\mu = \frac{4\gamma_D+3\gamma_S(1-\tau)}{2\gamma_S(4\gamma_D+\gamma_S(1-\tau))}$ $p_{b,S}^\mu - p_{b,S} = \frac{3\tau\gamma_S(1-\tau)^2}{(4\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0$
$p_{\beta,D}^\mu = \frac{2(1-\tau)}{(4\gamma_D+\gamma_S(1-\tau))}$ $p_{\beta,D}^\mu - p_{\beta,D} = \frac{(2\gamma_D-\gamma_S(1-\tau))\tau\gamma_S(1-\tau)^2}{\gamma_D(4\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0$, if $\gamma_S < \frac{2\gamma_D}{(1-\tau)}$	
$q_{b,D}^\mu = \frac{1}{2}$ $q_{b,D}^\mu - q_{b,D} = \frac{\gamma_S(1-\tau)^2}{2(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0$	$q_{b,S}^\mu = \frac{4\gamma_D-\gamma_S(1-\tau)}{2(4\gamma_D+\gamma_S(1-\tau))}$ $q_{b,S}^\mu - q_{b,S} = -\frac{3\tau\gamma_S^2(1-\tau)^2}{(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))(4\gamma_D+\gamma_S(1-\tau))} < 0$
$q_{\beta,D}^\mu = \frac{\gamma_S(1-\tau)}{2(4\gamma_D+\gamma_S(1-\tau))}$ $q_{\beta,D}^\mu - q_{\beta,D} = -\frac{\gamma_S(1-\tau)(4\gamma_D+\gamma_S(1-3\tau)(1-\tau))}{2(4\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} < 0$	

Table 2: Maximum Wholesale Margins, Regulation in D

D	S
$w_D^\mu = \frac{(1-\tau)(\gamma_D(2-\tau)+4\tau\gamma_S(1-\tau))}{2\gamma_D(\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$ $w_D^\mu - w_D = \frac{(1-\tau)^2(4\gamma_D-\gamma_S(2-3\tau)(1-\tau))}{2(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))(\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0$	$w_S^\mu = \frac{(3\tau+2)(1-\tau)}{2(\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$ $w_S^\mu - w_S = \frac{(3\tau+1)(1-\tau)(4\gamma_D-\gamma_S(2-3\tau)(1-\tau))}{2(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))(\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0$
$p_{b,D}^\mu = \frac{(2-\tau)\gamma_D+4\tau\gamma_S(1-\tau)}{2\gamma_D(\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$ $p_{b,D}^\mu - p_{b,D} = \frac{(1-\tau)(4\gamma_D-\gamma_S(2-3\tau)(1-\tau))}{2(\gamma_D+\gamma_S(3\tau+1)(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0$	$p_{b,S}^\mu = \frac{(3\tau+2)(1-\tau)}{2(\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$ $p_{b,S}^\mu - p_{b,S} = -\frac{4\gamma_D^2-\gamma_S\gamma_D(1-3\tau)(1-\tau)+\gamma_S^2(3\tau+1)(1-\tau)^2}{2\gamma_S(\gamma_D+\gamma_S(3\tau+1)(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} < 0$
$p_{\beta,D}^\mu = \frac{(1-\tau)(\gamma_D(2+\tau)+2\tau\gamma_S(1-\tau))}{2\gamma_D(\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$ $p_{\beta,D}^\mu - p_{\beta,D} = \frac{(\tau+1)(1-\tau)(4\gamma_D-\gamma_S(2-3\tau)(1-\tau))}{2(\gamma_D+\gamma_S(3\tau+1)(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0$	
$q_{b,D}^\mu = \frac{\gamma_D(2-\tau)+4\tau\gamma_S(1-\tau 1)}{2(\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$ $q_{b,D}^\mu - q_{b,D} = \frac{\gamma_D(1-\tau)(4\gamma_D-\gamma_S(2-3\tau)(1-\tau))}{2(\gamma_D+\gamma_S(3\tau+1)(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0$	$q_{b,S}^\mu = \frac{2\gamma_D+3\tau\gamma_S(1-\tau)}{2(\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$ $q_{b,S}^\mu - q_{b,S} = \frac{4\gamma_D^2-\gamma_S\gamma_D(1-3\tau)(1-\tau)+\gamma_S^2(3\tau+1)(1-\tau)^2}{2(\gamma_D+\gamma_S(3\tau+1)(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0$
$q_{\beta,D}^\mu = \frac{\gamma_S(1-\tau)-\gamma_D}{(\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0$, if $\gamma_S > \frac{\gamma_D}{(1-\tau)}$ $q_{\beta,D}^\mu - q_{\beta,D} = -\frac{\gamma_D(4\gamma_D-\gamma_S(2-3\tau)(1-\tau))}{(\gamma_D+\gamma_S(3\tau+1)(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} < 0$	

Table 3: Maximum Wholesale Margins, Regulation in S

D	S
$w_D^\mu = \frac{\gamma_D(2-\tau)+\tau\gamma_S(1-\tau)-2\gamma_D^2 m_D-2\gamma_S\gamma_D m_S(1-\tau)}{2\gamma_D(\gamma_D+\gamma_S(1-\tau))}$ $w_D^\mu - w_D = \frac{4\gamma_D^2-\gamma_S\gamma_D(1-\tau)\left(2-9\tau-\tau^2\right)-\tau\gamma_S^2(3-7\tau)(1-\tau)^2}{2\gamma_D(\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$ $-\frac{2\gamma_D(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))(\gamma_S m_S(1-\tau)+\gamma_D m_D)}{2\gamma_D(\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0$	$w_S^\mu = \frac{1-\tau-\gamma_S m_S(1-\tau)-\gamma_D m_D}{\gamma_D+\gamma_S(1-\tau)}$ $w_S^\mu - w_S = \frac{2\gamma_D(1-\tau)-\gamma_S(1-3\tau)(1-\tau)^2}{(\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$ $-\frac{(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))(\gamma_S m_S(1-\tau)+\gamma_D m_D)}{(\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0$
$p_{b,D}^\mu = \frac{\gamma_D(2-\tau)+\tau\gamma_S(1-\tau)+2\gamma_S\gamma_D(1-\tau)(m_D-m_S)}{2\gamma_D(\gamma_D+\gamma_S(1-\tau))}$ $p_{b,D}^\mu - p_{b,D} = \frac{(1-\tau)\left(4\gamma_D^2-\gamma_S\gamma_D(2-3\tau)(1-\tau)-3\tau\gamma_S^2(1-\tau)^2\right)}{2\gamma_D(\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$ $+\frac{(1-\tau)(2\gamma_S\gamma_D(m_D-m_S)(4\gamma_D+\gamma_S(3\tau+1)(1-\tau)))}{2\gamma_D(\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} \lesseqgtr 0$	$p_{b,S}^\mu = \frac{(1-\tau+\gamma_D(m_S-m_D))}{(\gamma_D+\gamma_S(1-\tau))}$ $p_{b,S}^\mu - p_{b,S} = \frac{-4\gamma_D^2+\gamma_S\gamma_D(1-3\tau)(1-\tau)-\gamma_S^2(1-3\tau)(1-\tau)^2}{2\gamma_S(\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$ $+\frac{2\gamma_S\gamma_D(m_S-m_D)(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}{2\gamma_S(\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} \lesseqgtr 0$
$p_{\beta,D}^\mu = \frac{(1-\tau)(1+\gamma_S(m_D-m_S))}{(\gamma_D+\gamma_S(1-\tau))}$ $p_{\beta,D}^\mu - p_{\beta,D} = \frac{(1-\tau)\left(2\gamma_D^2-\gamma_D\gamma_S(1-2\tau)(1-\tau)-\tau\gamma_S^2(1-\tau)^2\right)}{\gamma_D(\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$ $+\frac{(1-\tau)(\gamma_S\gamma_D(m_D-m_S)(4\gamma_D+\gamma_S(3\tau+1)(1-\tau)))}{\gamma_D(\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} \lesseqgtr 0$	
$q_{b,D}^\mu = \frac{1}{2}$ $q_{b,D}^\mu - q_{b,D} = \frac{\gamma_S(1-\tau)^2}{2(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0$	$q_{b,S}^\mu = \gamma_D\frac{1-\gamma_S(m_S-m_D)}{(\gamma_D+\gamma_S(1-\tau))}$ $q_{b,S}^\mu - q_{b,S} = \frac{4\gamma_D^2-\gamma_S\gamma_D(1-3\tau)(1-\tau)+\gamma_S^2(1-3\tau)(1-\tau)^2}{2(\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$ $-\frac{2\gamma_S\gamma_D(m_S-m_D)(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}{2(\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} \lesseqgtr 0$
$q_{\beta,D}^\mu = \frac{\gamma_S(1-\tau)-\gamma_D-2\gamma_S\gamma_D((m_D-m_S))}{2(\gamma_D+\gamma_S(1-\tau))}$ $q_{\beta,D}^\mu - q_{\beta,D} = -\frac{4\gamma_D^2-\gamma_S\gamma_D(1-3\tau)(1-\tau)+\gamma_S^2(1-3\tau)(1-\tau)^2}{2(\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$ $-\frac{2\gamma_S\gamma_D(m_D-m_S)(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}{2(\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} \lesseqgtr 0$	

Table 4: Maximum Wholesale Margins, Symmetric Equilibrium

For $m_D = m_S = 0$:
$p^{\mu}_{b,D} - p_{b,D} = \frac{(1-\tau)\left(4\gamma_D^2 - \gamma_S\gamma_D(2-3\tau)(1-\tau) - 3\tau\gamma_S^2(1-\tau)^2\right)}{2\gamma_D(\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0,$
if $\gamma_D > \widehat{\gamma_{D,H}} = \frac{1}{8}\gamma_S\left(1-\tau\right)\left(\sqrt{9\tau^2+36\tau+4} - 3\tau + 2\right)$
$p^{\mu}_{b,S} - p_{b,S} = \frac{-4\gamma_D^2 + \gamma_S\gamma_D(1-3\tau)(1-\tau) - \gamma_S^2(1-3\tau)(1-\tau)^2}{2\gamma_S(\gamma_D+\gamma_S(1-\tau))(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0,$
if $\gamma_D < \widehat{\gamma_{D,S}} = \frac{1}{8}\gamma_S\left(1-\tau\right)\left(\sqrt{3}\sqrt{\left(\tau+5\right)\left(3\tau-1\right)} - 3\tau + 1\right),$
with $\widehat{\gamma_{D,H}} > \widehat{\gamma_{D,S}}$.

D	S
$w_D^{\psi} = 0$ $w_D^{\psi} - w_D = -\frac{2(1-\tau)(\gamma_D+\tau\gamma_S(1-\tau))}{\gamma_D(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$	$w_S^{\psi} = \frac{2\tau(1-\tau)(5-\tau)}{\left(4\gamma_D(3\tau+1)+\tau\gamma_S(1-\tau)(\tau+3)^2\right)}$ $w_S^{\psi} - w_S = -\frac{8(1-\tau)^3(\gamma_D+\tau\gamma_S(1-\tau))}{\left(4\gamma_D(3\tau+1)+\tau\gamma_S(1-\tau)(\tau+3)^2\right)(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} < 0$
$p_{b,D}^{\psi} = \frac{2\tau(\tau+3)(\gamma_D+\tau\gamma_S(1-\tau))}{\gamma_D\left(4\gamma_D(3\tau+1)+\tau\gamma_S(1-\tau)(\tau+3)^2\right)}$ $p_{b,D}^{\psi} - p_{b,D} = -\frac{4(1-\tau)(\gamma_D+\tau\gamma_S(1-\tau))(2\gamma_D(\tau+1)+\tau\gamma_S(\tau+3)(1-\tau))}{\gamma_D\left(4\gamma_D(3\tau+1)+\tau\gamma_S(1-\tau)(\tau+3)^2\right)(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} < 0$	$p_{b,S}^{\psi} = \frac{\left(4\gamma_D(3\tau+1)+\tau\gamma_S(1-\tau)\left(4\tau+\tau^2+19\right)\right)}{2\gamma_S\left(4\gamma_D(3\tau+1)+\tau\gamma_S(1-\tau)(\tau+3)^2\right)}$ $p_{b,S}^{\psi} - p_{b,S} = -\frac{4(1-\tau)^3(\gamma_D+\tau\gamma_S(1-\tau))}{\left(4\gamma_D(3\tau+1)+\tau\gamma_S(1-\tau)(\tau+3)^2\right)(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} < 0$
$p_{\beta,D}^{\psi} = \frac{\tau(1-\tau)(8\gamma_D+\tau\gamma_S(\tau+3)(1-\tau))}{\gamma_D\left(4\gamma_D(3\tau+1)+\tau\gamma_S(1-\tau)(\tau+3)^2\right)}$ $p_{\beta,D}^{\psi} - p_{\beta,D} = -\frac{2(1-\tau)^2(\gamma_D+\tau\gamma_S(1-\tau))(4\gamma_D+\tau\gamma_S(\tau+3)(1-\tau))}{\gamma_D\left(4\gamma_D(3\tau+1)+\tau\gamma_S(1-\tau)(\tau+3)^2\right)(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} < 0$	
$q_{b,D}^{\psi} = \frac{2(\tau+3)(\gamma_D+\tau\gamma_S(1-\tau))}{\left(4\gamma_D(3\tau+1)+\tau\gamma_S(1-\tau)(\tau+3)^2\right)}$ $q_{b,D}^{\psi} - q_{b,D} = \frac{2(1-\tau)(\gamma_D+\tau\gamma_S(1-\tau))(8\gamma_D+\gamma_S(\tau+3)(1-\tau)(\tau+1))}{(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))\left(4\gamma_D(3\tau+1)+\tau\gamma_S(1-\tau)(\tau+3)^2\right)} > 0$	$q_{b,S}^{\psi} = \frac{4\gamma_D(3\tau+1)-\tau\gamma_S(1-\tau)\left(1-8\tau-\tau^2\right)}{2\left(4\gamma_D(3\tau+1)+\tau\gamma_S(1-\tau)(\tau+3)^2\right)}$ $q_{b,S}^{\psi} - q_{b,S} = \frac{4\gamma_S(1-\tau)^3(\gamma_D+\tau\gamma_S(1-\tau))}{(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))\left(4\gamma_D(3\tau+1)+\tau\gamma_S(1-\tau)(\tau+3)^2\right)} > 0$
$q_{\beta,D}^{\psi} = \frac{(1-\tau)(\tau\gamma_S(\tau+3)-2\gamma_D)}{4\gamma_D(3\tau+1)+\tau\gamma_S(1-\tau)(\tau+3)^2}$ $q_{\beta,D}^{\psi} - q_{\beta,D} = -\frac{2(1-\tau)(\gamma_D+\tau\gamma_S(1-\tau))(4\gamma_D+\gamma_S(\tau+3)(1-\tau))}{(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))\left(4\gamma_D(3\tau+1)+\tau\gamma_S(1-\tau)(\tau+3)^2\right)} < 0$	

Table 5: Manufacturer Discounts, Regulation in D

D	S
$w_D^\psi = 2\tau \frac{(1-\tau)}{\gamma_D(3\tau+1)}$ $w_D^\psi - w_D = -\frac{2(\tau-1)^2}{(3\tau+1)(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} < 0$	$w_S^\psi = 0$ $w_S^\psi - w_S = -\frac{2(1-\tau)}{4\gamma_D+\gamma_S(3\tau+1)(1-\tau)} < 0$
$p_{b,D}^\psi = \frac{2\tau}{\gamma_D(3\tau+1)}$ $p_{b,D}^\psi - p_{b,D} = -\frac{2(1-\tau)}{(3\tau+1)(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} < 0$	$p_{b,S}^\psi = \frac{1}{2\gamma_S}$ $p_{b,S}^\psi - p_{b,S} = -\frac{(1-\tau)}{(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} < 0$
$p_{\beta,D}^\psi = \frac{(1-\tau)\tau}{\gamma_D(3\tau+1)}$ $p_{\beta,D}^\psi - p_{\beta,D} = -\frac{2(1-\tau)(\tau+1)}{(3\tau+1)(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} < 0$	
$q_{b,D}^\psi = \frac{2\tau}{3\tau+1}$ $q_{b,D}^\psi - q_{b,D} = -\frac{2\gamma_D(1-\tau)}{(3\tau+1)(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} < 0$	$q_{b,S}^\psi = \frac{1}{2}$ $q_{b,S}^\psi - q_{b,S} = \frac{\gamma_S(1-\tau)}{(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0$
$q_{\beta,D}^\psi = \frac{1}{3\tau+1}$ $q_{\beta,D}^\psi - q_{\beta,D} = \frac{4\gamma_D}{(3\tau+1)(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0$	

Table 6: Manufacter Discounts, Regulation in S

D	S
$w_D^{\psi} = \frac{\psi_D 2(1-\tau)(\gamma_D+\tau\gamma_S(1-\tau))}{\gamma_D(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$ $w_D^{\psi} - w_D = -\frac{(1-\psi_D)2(1-\tau)(\gamma_D+\tau\gamma_S(1-\tau))}{\gamma_D(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} < 0$	$w_S^{\psi} = \frac{\psi_S 2(1-\tau)}{4\gamma_D+\gamma_S(3\tau+1)(1-\tau)}$ $w_S^{\psi} - w_S = -\frac{(1-\psi_S)2(1-\tau)}{4\gamma_D+\gamma_S(3\tau+1)(1-\tau)} < 0$
$p_{b,D}^{\psi} = \frac{8\tau\gamma_D+2\tau\gamma_S(3\tau+1)(1-\tau)+2\psi_S\gamma_D(1-\tau)+4\psi_D(1-\tau)(\gamma_D+\tau\gamma_S(1-\tau))}{\gamma_D(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))(\tau+3)}$ $p_{b,D}^{\psi} - p_{b,D} = -\frac{2(1-\tau)(3\gamma_D+2\tau\gamma_S(1-\tau)-\psi_S\gamma_D-2\psi_D(\gamma_D+\tau\gamma_S(1-\tau)))}{\gamma_D(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))(\tau+3)} < 0$	$p_{b,S}^{\psi} = \frac{4\gamma_D+\gamma_S(3\tau+1)(1-\tau)+2\gamma_S\psi_S(1-\tau)}{2\gamma_S(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$ $p_{b,S}^{\psi} - p_{b,S} = -\frac{(1-\tau)(1-\psi_S)}{(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} < 0$
$p_{\beta,D}^{\psi} = \frac{(1-\tau)(4\tau\gamma_D+\tau\gamma_S(3\tau+1)(1-\tau)+4\psi_S\gamma_D+2\psi_D(1-\tau)(\gamma_D+\tau\gamma_S(1-\tau)))}{\gamma_D(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))(\tau+3)}$ $p_{\beta,D}^{\psi} - p_{\beta,D} = -\frac{2(1-\tau)\left(\gamma_D(3-\tau)+\tau\gamma_S(1-\tau)^2-2\psi_S\gamma_D-\psi_D(1-\tau)(\gamma_D+\tau\gamma_S(1-\tau))\right)}{\gamma_D(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))(\tau+3)} < 0$	
$q_{b,D}^{\psi} = \frac{2\left(4\tau\gamma_D+\tau\gamma_S(3\tau+1)(1-\tau)+\psi_S\gamma_D(1-\tau)-\psi_D\left(1-\tau^2\right)(\gamma_D+\tau\gamma_S(1-\tau))\right)}{\tau(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))(\tau+3)}$ $q_{b,D}^{\psi} - q_{b,D} = \frac{2(1-\tau)\left(\tau\gamma_D+\tau\gamma_S\left(1-\tau^2\right)+\psi_S\gamma_D-\psi_D(\tau+1)(\gamma_D+\tau\gamma_S(1-\tau))\right)}{\tau(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))(\tau+3)} > 0$	$q_{b,S}^{\psi} = \frac{4\gamma_D+\gamma_S(3\tau+1)(1-\tau)-2\gamma_S\psi_S(1-\tau)}{2(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))}$ $q_{b,S}^{\psi} - q_{b,S} = \frac{(1-\psi_S)\gamma_S(1-\tau)}{(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))} > 0$
$q_{\beta,D}^{\psi} = \frac{4\tau\gamma_D+\tau\gamma_S(3\tau+1)(1-\tau)-2\psi_S\gamma_D(\tau+1)+2\psi_D(1-\tau)(\gamma_D+\tau\gamma_S(1-\tau))}{\tau(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))(\tau+3)}$ $q_{\beta,D}^{\psi} - q_{\beta,D} = \frac{2\left(2\tau\gamma_D-\tau\gamma_S(1-\tau)^2-\psi_S\gamma_D(\tau+1)+\psi_D(1-\tau)(\gamma_D+\tau\gamma_S(1-\tau))\right)}{\tau(4\gamma_D+\gamma_S(3\tau+1)(1-\tau))(\tau+3)} > 0$	

Table 7: Manufacturer Discounts, Symmetric Equilibrium