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investment incentives**

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Parallel trade, price regulation, and investment incentives

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ABSTRACT

We study the case where parallel trade (PT) stems from government price controls in a foreign country. We remove the presumption that PT blunts dynamic efficiency if the government has partial commitment ability. We model the R&D firm's option to serve the foreign country, and find that PT may improve quality, depending on preferences for quality. Improving quality may be a sufficient condition for PT to raise global welfare *ex ante*. Under PT, quality may be higher with than without price controls. We discuss the role of bargaining power in price negotiations.

JEL Classification: L51, F1, O34

Keywords: Parallel trade; Price regulation; R&D investment; Intellectual property rights

1. Introduction

Different countries may have different policies as to the protection of intellectual property rights (IPR).¹ A key example is the EU pharmaceutical industry, where different regulatory regimes for prescription drugs cause cross-country differences in prices. Price differentials are the main reason of parallel trade (PT). This consists of buying products in a country, and exporting them

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¹ Some countries allow IPR owners to set prices that foster R&D investment in the long run (dynamic efficiency). Instead, other countries impose price controls to ensure affordability of products in the short run (static efficiency).

to another country, without the IPR owner's assent.² The EU promotes free circulation of goods to achieve the single market,³ but PT weakens a country's ability to accept high prices to support R&D. It emerges a conflict between integration in sales and segmentation in regulatory regimes.

Thus, a hotly debated policy issue is: under segmented regulation, should PT in IPR products be allowed, because of the alleged positive *ex post* (i.e. when R&D investment is sunk) welfare effects, or rather banned, due to the expected negative *ex ante* impact on investment incentives?

We address this issue through a vertical pricing model of PT with endogenous quality choice, where the IPR owner sells directly at home, and abroad via an independent firm. Prices are free at home but regulated abroad. The foreign government negotiates the wholesale price (for health insurance organizations) with the IPR owner⁴ in a Nash bargaining game (see Pecorino, 2002).

The foreign government should consider the IPR owner's outside option not to sell abroad.⁵ Product quality may thus improve under PT, conditional on the relative preferences for quality of consumers in the two countries. We find that PT raises (respectively, reduces) *ex post* global welfare if and only if demand dispersion between countries is small (large) enough. Then, improving quality may be a sufficient (necessary) condition for PT to raise welfare *ex ante*. We also find that, under PT, price regulation may improve quality relative to the unregulated case.

A few papers study the effect of PT on product quality under price regulation. Rey (2003) shows that, for given regulated prices, PT reduces world investment in technology. Grossman and Lai (2008), instead, remark that the foreign government should provide the R&D firm with

² EU pharmaceutical PT amounts to € 5,465 million at ex-factory prices (EFPIA, *The pharmaceutical industry in figures*, 2014; <http://www.efpia.eu>), with high market shares for patented drugs (Kanavos and Costa-Font, 2005).

³ The regime of territorial exhaustion of IPR sets the legality of PT. Under regional exhaustion (as in the EU), IPR are ended upon first sale inside the region, but are not exhausted outside. Under national exhaustion (as in the US), IPR hold for imported products. International exhaustion (as in developing countries) supports trade liberalization.

⁴ This is often the case for prescription drugs in the EU (Kanavos and Costa-Font, 2005).

⁵ Indeed, R&D firms have been delaying the launch of new drugs in low-price EU countries (Kyle, 2007), which in turn, under pharmaceutical PT, have raised prices closer to the EU average (Kanavos and Costa-Font, 2005).

suitable incentives to sell abroad. They find that, if the government can fully commit to price before the R&D firm invests, international exhaustion may boost innovation and the domestic consumer surplus. Bennato and Valletti (2014) test the effect of different levels of commitment. They confirm that PT may improve quality (and global welfare) only when the foreign government fully commits, which is equivalent to a withdrawal from price regulation.

Different from these papers, we find that quality and welfare may be higher with than without PT, even when the foreign government has partial commitment ability.

This paper is organized as follows. Section 2 presents the model. Sections 3 and 4 solve the cases of national and international exhaustion. Section 5 analyzes the results, and the impact of bargaining power and price regulation. Section 6 provides an example. Section 7 concludes.

2. The model

A manufacturer (firm M) sells a good (e.g. a drug) in country 1 through a controlled subsidiary, and in country 2 via an independent distributor (firm D). The local government G in country 2 negotiates the wholesale price w to firm D through Nash bargaining with firm M , and sets the retail price. Firm D may parallel export the good to country 1 at no cost. Retail costs are zero.

Consider a three-stage game.⁶ At stage one, firm M carries out R&D and sets product quality $x > 0$ at cost $C(x)$, where $C'(x) > 0$ and $C''(x) > 0$. At stage two, firm M produces the good at zero marginal cost and negotiates the wholesale price with G . At stage three, G sets the retail price in country 2. Should PT take place, firms M and D compete in quantities in country 1.

Let $p_j = a_j(x) - Q_j$ be the inverse demand curve in country j ($j = 1, 2$), where p_j is the price of the product. In country 1, when PT takes place we have $Q_1 = q_1 + q_t$, where q_1 is the

⁶ Price negotiations occur when firm M has already invested in quality. For instance, pharmaceutical R&D costs are mostly sunk by the time the drug is launched and prices are set. Moreover, R&D investment is not country-specific, but is for any country where firm M may sell the drug. As is standard in vertical pricing models of PT (beginning with Maskus and Chen, 2004), we assume Cournot competition in the PT-recipient country.

quantity sold by firm M and q_t are parallel imports. In country 2, the monopolist firm D sells $Q_2 = q_2$. We assume $a_j(x) > 0$ and $a_j'(x) > 0$ ($j = 1, 2$) –for convenience, we sometimes use primes to denote derivatives of functions with respect to (wrt) their arguments. Thus, consumers in the two countries differ in their willingness to pay (wtp) for the product and in their marginal valuation of quality, because of cross-country differences in income and/or product needs.⁷

Let $\theta(x) = a_2(x)/a_1(x)$ measure the demand dispersion between countries. We restrict the set of feasible qualities to limit demand dispersion. To fix ideas, we assume that consumers' maximum wtp is higher in country 1 than in country 2. Instead, the lower bound on $\theta(x)$ means that such wtp is not too much higher in country 1, and ensures that firm M serves country 2 even under PT. In so doing, we also avoid corner solutions where PT is deterred or blocked.

Assumption 1. Let $x \in X = \{x: \underline{\theta} < \theta(x) < 1\}$, where $\underline{\theta} = (108\sqrt{35} - 265)/1009 \approx 0.371$.

Table 1 reports firms' profit functions, consumer surplus in each country and global welfare under national exhaustion (regime n) and international exhaustion (regime i) of IPR.

regime n	regime i
$\pi_M^n = p_1 q_1 + w q_2 - C(x)$	$\pi_M^i = p_1 q_1 + w(q_2 + q_t) - C(x)$
$\pi_D^n = (p_2 - w)q_2$	$\pi_D^i = (p_1 - w)q_t + (p_2 - w)q_2$
$CS^n = CS_1^n + CS_2^n = q_1^2/2 + q_2^2/2$	$CS^i = CS_1^i + CS_2^i = (q_1 + q_t)^2/2 + q_2^2/2$
$W^n = CS_1^n + CS_2^n + \pi_M^n + \pi_D^n$	$W^i = CS_1^i + CS_2^i + \pi_M^i + \pi_D^i$

Table 1. Firms' profit functions, consumer surplus and social welfare in each IPR regime.

3. National exhaustion

In regime n , PT is banned. At stage three, G sets the retail price in country 2 that maximizes consumer surplus (or equivalently, local welfare) subject to firm D 's budget constraint. We find $p_2^n(w, x) = w(x)$. In country 1, the FOC on M 's profit wrt quantity gives $q_1^n(x) = a_1(x)/2$.

⁷ The demand curve in any country may derive from the utility of consumers who are uniformly distributed in their basic wtp for the product, and homogeneous in their valuation of quality (see e.g. Matteucci and Reverberi, 2014a). Qualitative results hold for different demands if quality improvements imply parallel upward shifts in demands.

At stage two, M and G negotiate the wholesale price by Nash bargaining. Firm M 's profit without an agreement (M 's threat point) is the monopoly profit $\pi_M^*(x)$ in country 1 (superscript $*$ denotes autarchy). Since $q_1^*(x) = q_1^n(x) = a_1(x)/2$, then $\pi_M^*(x) = a_1(x)^2/4 - C(x)$. If M does not serve country 2, consumer surplus in country 2 is zero. Hence, zero is G 's threat point.

Let α reflect G 's bargaining power. The wholesale price solves the Nash bargaining problem NBP^n : $\max_w (CS_2^n(w, x))^\alpha (\pi_M^n(w, x) - \pi_M^*(x))^{1-\alpha}$, where we have inserted for $p_2^n(w, x)$ in $CS_2^n(\cdot)$ and $\pi_M^n(\cdot)$. The FOC to NBP^n wrt w implies:⁸ $\frac{\alpha(\pi_M^n(w^n, x) - \pi_M^*(x))}{q_2^n(w^n, x)} = \frac{(1-\alpha)}{2} \frac{\partial \pi_M^n(w, x)}{\partial w} \Big|_{w^n}$. We focus on symmetric Nash bargaining, where $\alpha = 1/2$ ⁹ (in section 5.3, we discuss the cases where all the bargaining power is on G 's side, i.e. $\alpha = 1$, or on M 's side, i.e. $\alpha = 0$). Thus, the optimal wholesale price is $w^n(x) = a_2(x)/4 = a_1(x)\theta(x)/4$ (the SOC is fulfilled).

At stage one, the FOC on M 's profit wrt x yields the optimal quality x^n (assuming an interior solution), that is, $(\partial \pi_M^n(x)/\partial x)|_{x^n} = 0$, given that the SOC holds (i.e. $\partial^2 \pi_M^n(x)/\partial x^2 < 0$).

4. International exhaustion

In regime i , at stage three, G sets p_2 to maximize consumer surplus subject to firm D 's budget constraint.¹⁰ Since $CS_2^i(\cdot)$ declines with p_2 then $p_2^i(w, x) = w(x)$. In country 1, firms M and D compete *à la* Cournot. Hence, $q_1^i(w, x) = (a_1(x) + w)/3$ and $q_t(w, x) = (a_1(x) - 2w)/3$.

At stage two, M and G negotiate the wholesale price, with the same threat points as in regime n . The optimal wholesale price solves NBP^i : $\max_w (CS_2^i(w, x))^\alpha (\pi_M^i(w, x) - \pi_M^*(x))^{1-\alpha}$, where we have inserted for $p_2^i(w, x)$ in $CS_2^i(\cdot)$ and $\pi_M^i(\cdot)$. The FOC to NBP^i wrt w implies:

⁸ Recall that $CS_2^n(w, x) = q_2^n(w, x)^2/2$ and $\partial CS_2^n(w, x)/\partial w = -q_2^n(w, x)$.

⁹ By simple algebra, we can rewrite the FOC to NBP^n (with $\alpha = 1/2$) wrt w as: $\frac{(a_2(x) - 4w)(a_2(x) - w)}{2\sqrt{2}\sqrt{w(a_2(x) - w)}} = 0$.

¹⁰ In regime i , this is the same as maximizing the weighted welfare $W_2^i(p_2, w, x) = CS_2^i(p_2, w, x) + \beta \pi_D^i(p_2, w, x)$, where $\beta \in [0, 1)$ is low enough that $W_2^i(\cdot)$ decreases with p_2 .

$$\frac{\alpha(\pi_M^i(w^i, x) - \pi_M^*(x))}{q_2^i(w^i, x)} = \frac{(1-\alpha)}{2} \frac{\partial \pi_M^i(w, x)}{\partial w} \Big|_{w^i}. \text{ Let } \alpha = 1/2.^{11} \text{ We thus find } w^i(x) = a_1(x)\rho(\theta(x)),$$

where $\rho(\theta(x)) = (15 + 55\theta(x) - \sqrt{\theta(x)(1009\theta(x) + 530) - 335})/112$ (the SOC holds).

Assumption 1 ensures that $\rho(\theta(x)) \in \mathbb{R}$ and firm M 's participation constraint is fulfilled.

At stage one, the FOC on M 's profit wrt x yields the optimal quality x^i (assuming an interior solution), that is, $(\partial \pi_M^i(x)/\partial x)|_{x^i} = 0$, given that the SOC holds (i.e. $\partial^2 \pi_M^i(x)/\partial x^2 < 0$).¹²

5. Comparison between regimes

We now assess how PT affects quality (section 5.1) and welfare (section 5.2). Then, we discuss the role of bargaining power (section 5.3) and the impact of price regulation (section 5.4).

5.1 Product quality

We find that PT may improve quality. Proposition 1 shows that a necessary and sufficient condition for PT to improve quality is that, at the equilibrium quality level in regime n , consumers in country 2 have a sufficiently high marginal wtp for quality.¹³

Let $\eta_\pi(\theta(x)) = \frac{\theta(x)}{\pi_M^i(x) - \pi_M^n(x)} \frac{\partial(\pi_M^i(x) - \pi_M^n(x))}{\partial \theta(x)}$ be the elasticity of firm M 's profit variation

$\pi_M^i(x) - \pi_M^n(x)$, due to a shift in the IPR regime, wrt the demand dispersion between countries $\theta(x)$ (from Assumption 1, $\eta_\pi(\theta(x)) \neq 0$). We will use $\eta_\pi(\theta(x))$ to prove the proposition.

Proposition 1. PT improves quality if and only if consumers' marginal valuation of quality in country 2, at the equilibrium quality level under national exhaustion, is sufficiently high.

¹¹ We can rewrite the FOC to NBP^i (with $\alpha = 1/2$) wrt w as: $\frac{a_1(x)^2(2\theta(x)(9\theta(x)+5)+5)+112w^2-10wa_1(x)(11\theta(x)+3)}{6\sqrt{2}\sqrt{4wa_1(x)(9\theta(x)+5)-5a_1(x)^2-56w^2}} = 0$.

¹² In pharmaceuticals, firm D is often subject to the public service obligation to serve country 2. Then, in regime i , G might set $p_2^i(w, x)$ below the wholesale price and yet ensure a (worldwide) normal profit to D , which gains from parallel exports to country 1. Unless otherwise stated, the qualitative results of our basic model still hold.

¹³ For product qualities in regimes i and n to be suitably compared, the cost function must be sufficiently convex.

Proof of Proposition 1. Firm M 's profit at stage two is $\pi_M^n(x) = (a_1(x)^2/4)(1 + 3\theta(x)^2/4) - C(x)$ in regime n and $\pi_M^i(x) = (a_1(x)^2/9)((9\theta(x) + 5 - 14\rho(\theta(x)))\rho(\theta(x)) + 1) - C(x)$ in regime i . We can thus write $\pi_M^i(x) - \pi_M^n(x) = a_1(x)^2 f(\theta(x))$, or equivalently $f(\theta(x)) = (\pi_M^i(x) - \pi_M^n(x))/a_1(x)^2$. Let $f'(\theta(x)) = (\partial(\pi_M^i(x) - \pi_M^n(x))/\partial\theta(x))(1/a_1(x)^2)$ (with a slight abuse of notation). We find that $\partial(\pi_M^i(x) - \pi_M^n(x))/\partial x = 2a_1(x)a_1'(x)f(\theta(x)) + a_1(x)^2 f'(\theta(x))\theta'(x)$. Inserting $f(\theta(x))$ and $f'(\theta(x))$, we find $\partial(\pi_M^i(x) - \pi_M^n(x))/\partial x = 2a_1'(x)(\pi_M^i(x) - \pi_M^n(x))/a_1(x) + (\partial(\pi_M^i(x) - \pi_M^n(x))/\partial\theta(x))\theta'(x)$.

From $\partial^2 \pi_M^k(x)/\partial x^2 < 0$, we have $\partial \pi_M^k(x)/\partial x > 0$ for $0 < x < x^k$ ($k = i, n$) and, from the FOC, $(\partial \pi_M^n(x)/\partial x)|_{x^n} = 0$. Let $x = x^n$. We find that: $\frac{\partial \pi_M^i(x)}{\partial x} \Big|_{x^n} = \frac{\partial(\pi_M^i(x) - \pi_M^n(x))}{\partial x} \Big|_{x^n} = 2a_1'(x^n) \frac{\pi_M^i(x^n) - \pi_M^n(x^n)}{a_1(x^n)} + \frac{\partial(\pi_M^i(x^n) - \pi_M^n(x^n))}{\partial\theta(x^n)} \theta'(x^n)$. Recall, at this point, that $\eta_\pi(\theta(x^n)) = \frac{\theta(x^n)}{\pi_M^i(x^n) - \pi_M^n(x^n)} \frac{\partial(\pi_M^i(x^n) - \pi_M^n(x^n))}{\partial\theta(x^n)} \neq 0$. Therefore, we have $\frac{\partial \pi_M^i(x)}{\partial x} \Big|_{x^n} > 0$ if and only if $2 \frac{\pi_M^i(x^n) - \pi_M^n(x^n)}{\partial(\pi_M^i(x^n) - \pi_M^n(x^n))/\partial\theta(x^n)} \frac{a_1'(x^n)}{a_1(x^n)} + \theta'(x^n) = \frac{2\theta(x^n)}{\eta_\pi(\theta(x^n))} \frac{a_1'(x^n)}{a_1(x^n)} + \theta'(x^n) > 0$, where we have $\partial(\pi_M^i(x) - \pi_M^n(x))/\partial\theta(x) > 0$ for any x under Assumption 1. Finally, inserting $\theta'(x^n) = a_2'(x^n)/a_1(x^n) - (\theta(x^n)a_1'(x^n))/a_1(x^n)$ and rearranging we have $(\partial \pi_M^i(x)/\partial x)|_{x^n} > 0$ if and only if $a_2'(x^n) > \theta(x^n)(1 - 2/\eta_\pi(\theta(x^n)))a_1'(x^n)$. Hence, in such a case, $x^i > x^n$. ■

5.2 Social welfare

We find that PT has an ambiguous effect on *ex post* global welfare. For a given quality, global welfare is higher in regime i than in regime n , if and only if the demand dispersion between countries is sufficiently small (i.e. $\theta(x)$ is high enough), otherwise it is lower.

*Proposition 2. PT raises ex post global welfare if and only if demand dispersion is low enough.*¹⁴

Proof of Proposition 2. Global welfare at stage two is $W^n(x) = a_1(x)^2 (3/8 + 15\theta(x)^2/32) - C(x)$ in regime n and $W^i(x) = a_1(x)^2 \xi(\theta(x)) - C(x)$ in regime i , where $\xi(\theta(x)) = (8 + 9\theta(x)^2 - 2\rho(\theta(x))(5\rho(\theta(x)) + 1))/18$. Under Assumption 1, $\xi(\theta(x))$ and $(3/8 + 15\theta(x)^2/32)$ rise with $\theta(x)$. We find that $\xi(\theta(x))$ crosses $(3/8 + 15\theta(x)^2/32)$ once in $\theta_W = 0.393$. We also find that, when $\theta(x) = \underline{\theta}$, $W^i(x) - W^n(x) = a_1(x)^2 (\xi(\underline{\theta}) - (3/8 + 15\underline{\theta}^2/32)) \approx -0.017a_1(x)^2 < 0$. Hence, $W^i(x) > W^n(x)$ for $\theta_W < \theta(x) < 1$. ■

Proposition 3 studies the effects of PT on welfare *ex ante*.¹⁵ Assume that a higher quality does not imply a larger demand dispersion (i.e. $\theta'(x) \geq 0$). Then, if PT raises welfare *ex post*, it also raises welfare *ex ante* when it improves quality relative to regime n . Instead, if PT dilutes welfare *ex post*, improving quality is a necessary condition for PT to raise welfare *ex ante*.

Proposition 3. Assume that demand dispersion does not increase with quality. Then, improving quality is a sufficient (respectively, necessary) condition for PT to increase global welfare ex ante when PT increases (respectively, reduces) welfare ex post.

Proof of Proposition 3. Assume $\theta'(x) \geq 0$. To prove the sufficient part, let $x^i > x^n$ and (from Proposition 2) $\theta_W < \theta(x) < 1$. Since $(\partial\pi_M^i(x)/\partial x)|_{x^i} = 0$, we can write $(\partial W^i(x)/\partial x)|_{x^i} = (\partial CS^i(x)/\partial x)|_{x^i} + (\partial\pi_M^i(x)/\partial x)|_{x^i} + (\partial\pi_D^i(x)/\partial x)|_{x^i} = (\partial(CS^i(x) + \pi_D^i(x))/\partial x)|_{x^i}$.

We can find that $CS^i(x) + \pi_D^i(x) = a_1(x)^2 \gamma(\theta(x))$, where (for brevity) $\gamma(\theta(x)) =$

¹⁴ According to the classic theory of third-degree price discrimination, PT improves *ex post* welfare when demand dispersion is small (Malueg and Schwartz, 1994). The novelty of our vertical pricing model is that PT may reduce global welfare despite all countries are served. However, we can prove that, if the government could set the retail price in country 2 below the wholesale price (see footnote 12), then PT would definitely improve *ex post* welfare.

¹⁵ Interestingly, we find that, contrary to the case where R&D investment is sunk, when quality is endogenous consumer surplus may rise in the PT-source country, or fall in the PT-recipient country. For brevity, we omit the proof, and refer the reader to Matteucci and Reverberi (2014a), who prove the same result in an unregulated model.

$(6\rho(\theta(x))^2 - 2(3\theta(x) + 2)\rho(\theta(x)) + 3\theta(x)^2 + 2)/6$, with $\gamma(\theta(x)) > 0$. We also find that $(\partial(CS^i(x) + \pi_D^i(x))/\partial x) = a_1(x) \left(a_1(x)\gamma'(\theta(x))\theta'(x) + 2a_1'(x)\gamma(\theta(x)) \right) > 0$ since $\theta'(x) \geq 0$ and, by some algebra, we can find that $\gamma'(\theta(x)) = (6219\theta(x) - 2705)/9408 + (3027\theta(x)^2 + 34994\theta(x) + 8375)/(9408\sqrt{\theta(x)(1009\theta(x) + 530) - 335}) > 0$.

It follows that $(\partial CS^i(x)/\partial x)|_{x^i} + (\partial \pi_D^i(x)/\partial x)|_{x^i} > 0$. Since we have $(\partial \pi_M^i(x)/\partial x) \geq 0$ for $0 < x \leq x^i$, we can find that $(\partial W^i(x)/\partial x) \geq (\partial W^i(x)/\partial x)|_{x^i} = (\partial CS^i(x)/\partial x)|_{x^i} + (\partial \pi_D^i(x)/\partial x)|_{x^i} > 0$ for $0 < x \leq x^i$. Then, having assumed that $x^i > x^n$ and $\theta_W < \theta(x) < 1$, we can find that $W^i(x^i) - W^n(x^n) > W^i(x^n) - W^n(x^n) > 0$.

To prove the necessary part, let now $x^i < x^n$ and $\underline{\theta} < \theta(x) < \theta_W$. It follows that $W^i(x^i) - W^n(x^n) < W^i(x^n) - W^n(x^n) < 0$. ■

5.3 The impact of the allocation of bargaining power

Let us discuss how the results depend on the allocation of bargaining power in price negotiation. First, consider the case where G has all the bargaining power (i.e. $\alpha = 1$). The wholesale price in regime k ($k = i, n$) solves $\max_w \left(CS_2^k(w, x) \right)$, subject to firm M 's participation constraint. Firm M retains the option not to serve country 2. Then, in regime i , it is allowed to recoup the opportunity cost of exporting quality, namely, the domestic profit loss due to PT (see also Matteucci and Reverberi, 2014b). Hence, we find that quality is independent of the IPR regime.

Proposition 4. When country 2 has all the bargaining power, PT does not affect quality.

Proof of Proposition 4. From sections 3 and 4, we simply find that the FOC to NBP^k (with $\alpha = 1$) implies that w^k ensures $\pi_M^k(w^k, x) = \pi_M^*(x)$, $k = i, n$. Then, at stage one, firm M maximizes $\pi_M^k(w^k, x) = \pi_M^*(x) = a_1(x)^2/4 - C(x)$, $k = i, n$. Therefore, when $\alpha = 1$, $x^i = x^n = x^*$. ■

We find that PT raises global welfare relative to regime n . While M 's profit is not affected, D 's profit is higher under PT. Since quality is the same in both regimes, PT only affects the

quantity sold. If demand dispersion is large, PT raises consumer surplus in country 1 more than it reduces surplus in country 2. Hence, PT raises global welfare. If demand dispersion is small, PT dilutes total consumer surplus, but not so much as to outweigh the increase in industry profit.

Consider now the case where M has all the bargaining power (i.e. $\alpha = 0$). The wholesale price in regime k ($k = i, n$) solves $\max_w \left(\pi_M^k(w, x) - \pi_M^*(x) \right)$, and thus $(\partial \pi_M^k(w, x) / \partial w)|_{w^k} = 0$. When $\alpha = 0$, we find $\eta_\pi(\theta(x)) = -2\theta(x)/(1 - \theta(x))$ (from Assumption 1, $\eta_\pi(\theta(x)) \neq 0$). Then, we have $\theta(x^n) (1 - 2/\eta_\pi(\theta(x^n))) = 1$. It follows (from Proposition 1) that $x^i > x^n$ if and only if $a_2'(x^n) > a_1'(x^n)$. Thus, PT raises quality if and only if consumers' marginal valuation of quality, at the equilibrium quality in regime n , is higher in country 2 than in country 1. We also find conditions under which global welfare *ex ante* is higher with than without PT.¹⁶

5.4 The impact of price regulation

Let us now consider the impact of price regulation on quality under PT. We thus compare qualities in regime i when country 2 is regulated (given that $\alpha = 1/2$) and when it is not.

Assume that, at stage three, firm D sets the retail price in country 2 and, at stage two, firm M sets the wholesale price to maximize profit. In such a case, Matteucci and Reverberi (2014a) find that (superscript u stands for the unregulated case): $w^u(x) = a_1(x)(\theta(x)/2 + 5(1 - \theta(x))/19)$. At stage one, in an interior solution, quality derives from the FOC on M 's profit $\pi_M^u(x) = (a_1(x)^2/152)(\theta(x)(9\theta(x) + 20) + 28) - C(x)$, where we have inserted for $w^u(x)$, wrt x (given that the SOC holds). Let $x^u \in X$ be the interior solution to the FOC.¹⁷

Proposition 5 shows that, contrary to common wisdom, quality under PT may be higher when country 2 is regulated than when it is not. For this to occur, consumers' marginal valuation

¹⁶ Further details on the cases where $\alpha = 1$ and $\alpha = 0$ (and the formal proofs) are available from the authors.

¹⁷ Condition $10/19 < \theta(x) < 1$ serves to ensure that all equilibrium quantities are positive absent regulation (Matteucci and Reverberi, 2014a). For comparison purposes, we assume here that this condition holds.

of quality in country 2, at the equilibrium quality level in case u , must be high enough. Let

$$\eta_u(\theta(x)) = \frac{\theta(x)}{\pi_M^i(x) - \pi_M^u(x)} \frac{\partial(\pi_M^i(x) - \pi_M^u(x))}{\partial \theta(x)} \neq 0$$

be the elasticity of firm M 's profit variation, due to a shift from the regulated to the unregulated case under PT, wrt demand dispersion.

Proposition 5. Under PT, price regulation improves quality if and only if consumers' marginal valuation of quality in country 2, at the equilibrium quality without regulation, is high enough.

Proof of Proposition 5. The proof follows the same steps as for Proposition 1 (we omit details).

Indeed, it suffices to replace $\pi_M^n(x)$ with $\pi_M^u(x)$, x^n with x^u , and $\eta_\pi(\theta(x^n))$ with $\eta_u(\theta(x^u))$.

We can thus find that $x^i > x^u$ if and only if $a_2'(x^u) > \theta(x^u)(1 - 2/\eta_u(\theta(x^u)))a_1'(x^u)$. ■

6. An example

Consider a case with quadratic costs and linear demand. Let $C(x) = x^2/2$, $a_1(x) = 1 + x$, and $a_2(x) = \theta(1 + x)$. Thus, $\theta(x) = a_2(x)/a_1(x) = \theta$, where $\underline{\theta} < \theta < 1$. We can find: $\pi_M^n(x) = ((1 + x)^2/4)(1 + 3\theta^2/4) - x^2/2$, and $\pi_M^i(x) = (1 + x)^2\phi(\theta) - x^2/2$, with $\phi(\theta) = (\theta(19\sqrt{\theta(1009\theta + 530)} - 335 - 37\theta + 550) - 5\sqrt{\theta(1009\theta + 530)} - 335 + 803)/4032$.

The FOCs on M 's profits yield $x^n = (4 + 3\theta^2)/(4 - 3\theta^2)$ and $x^i = 2\phi(\theta)/(1 - 2\phi(\theta))$ (under Assumption 1, the SOC's hold). Since $a_2'(x^n) = \theta$ and $a_1'(x^n) = 1$, from Proposition 1 we find that $x^i > x^n$ if and only if $1 > (1 - 2/\eta_\pi(\theta))$, which holds for $\theta > 0.78$. From propositions 2 and 3, $\theta > 0.78$ is sufficient for $W^i(x^i) > W^n(x^n)$. Figure 1 shows the results.

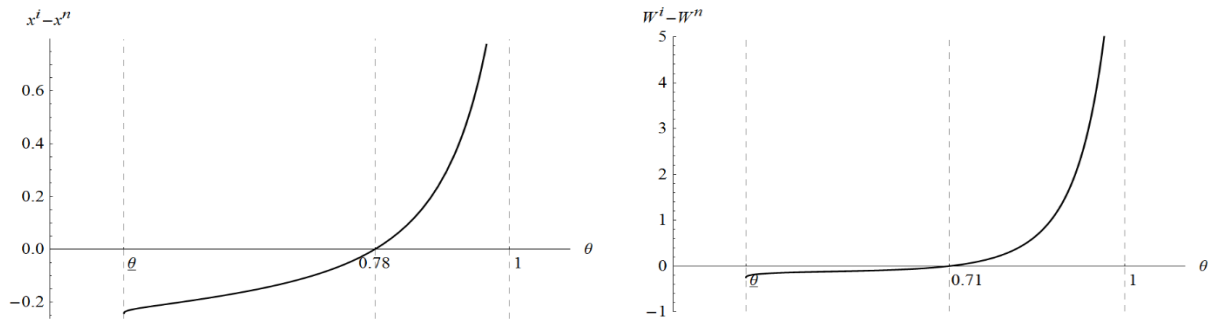


Figure 1. The effect of parallel trade on product quality (left panel) and global welfare (right panel), depending on demand dispersion between countries.

In the absence of regulation, we find that $\pi_M^u(x) = ((x + 1)^2(\theta(9\theta + 20) + 28)/152) - x^2/2$. The FOC on firm M 's profit yields $x^u = (76/(48 - \theta(9\theta + 20))) - 1$ (the SOC is fulfilled). From Proposition 5, we have that $x^i > x^u$ if and only if $1 > (1 - 2/\eta_u(\theta))$, which holds for any feasible θ (since $\eta_u(\theta) > 2$).

7. Concluding remarks

We have studied the welfare effects of PT stemming from national differences in government price controls. In our model, the foreign government has to negotiate prices to induce the R&D firm to serve the foreign country. We have shown that quality is higher with than without PT if and only if foreign consumers' marginal valuation of quality is high enough (when the government has all the bargaining power, quality is independent of the IPR regime). Under PT, quality may be higher with price regulation than when the R&D firm freely sets prices.

PT raises *ex post* global welfare if and only if demand dispersion is small enough (but it may reduce welfare even if all countries are served). In such a case, improving quality is a sufficient condition for PT to raise welfare *ex ante*, if demand dispersion does not increase with quality.

Although empirical studies are needed to support our theoretical findings, we have removed the presumption that PT in regulated industries with IPR protection (such as pharmaceuticals) has an adverse effect on dynamic efficiency, if governments have partial commitment ability.

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