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THE DESIGN OF EXTERNAL REFERENCE PRICING SCHEMES AND THE CHOICE OF REFERENCE COUNTRIES AND PRICING RULES

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The Design of External Reference Pricing Schemes and the Choice of Reference Countries and Pricing Rules

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Abstract

External reference pricing imposes a price cap for drugs based on prices in other countries. This paper studies the design of external reference pricing schemes, i.e., the choice of reference countries and pricing rules, in a three-country-framework. Given that the manufacturer sells to all three countries, the minimum price-rule yields the lowest drug price. As external reference pricing may increase the drug price in the reference country, it creates the incentive for the reference countries to also adopt external reference pricing. Thus external reference pricing results in regulatory convergence and a uniform price among all countries, i.e., price convergence. If the referencing country is sufficiently large, the manufacturer may not export to reference countries under the minimum price-rule. Then the average price-rule may safeguard exports to reference countries and generate a lower drug price in the referencing country.

JEL classification: F12, I11, I18
Keywords: external reference pricing, pharmaceutical regulation

1 Introduction

A widely used instrument in pharmaceutical price regulation is external reference pricing, which imposes a price cap for drugs based on their prices in other countries (Espin & Rovira, 2007). This is, external reference pricing follows the idea that prices in different countries may be compared. It is an easily applicable regulatory instrument, which requires no (additional) information, e.g., on the therapeutic value of a drug. Almost

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all European countries apply external reference pricing[1], with schemes varying in the number of reference countries and pricing rules. For instance, Portugal refers to prices in 3 other countries, while Italy uses 27 reference countries[2]. In Austria, the reference price is calculated as the average price in the reference countries, while Spain uses the minimum price (Toumi et al., 2013).

Garcia Mariñoso, Jelovac & Olivella (2011) and Ackermann (2010) analyze the incentives for countries to adopt external reference pricing. A country prefers external reference pricing against individual price negotiations with a firm under high copayments (Garcia Mariñoso, Jelovac & Olivella, 2011) or low bargaining power of its regulatory agency (Ackermann, 2010).

By making pricing decisions for different countries interdependent, external reference pricing may result in a (downward) price convergence (Toumi et al., 2013). Stargardt & Schreyögg (2006) study the impact of a price change in Germany on pharmaceutical prices in other countries under external reference pricing. They show that a €1-price reduction in Germany reduces prices from €0.15 in Austria to €0.36 in Italy. These price spillovers may induce firms to delay or even limit supply to low-price countries to (temporarily) retain high prices in other countries (Richter, 2008). Danzon, Wang & Wang (2005) who analyze launches of new drugs in 25 countries between 1994 and 1998, find that parallel exporting countries with relatively low drug prices have fewer launches and longer launch delays. Moreover, Danzon & Epstein (2008), Verniers, Stremersch & Croux (2011), Costa-Font, McGuire & Varol (2014) suggest that stricter regulation and/or interdependence between countries lead to greater launch delays. Houy & Jelovac (2015) study timing decisions of pharmaceutical firms when launching a drug under external reference pricing. They find no incentive to delay the launch when the countries only refer to the prices of a subset of all countries in a transitive way and any period. Persson & Jönsson (2015) argue that applying external reference pricing is attractive but costly, as it induces manufacturers to limit or delay launches and reduces opportunities for price discrimination among countries.

While the effect of reference pricing on launch delays has gained considerable attention in the literature, the choice of the design of external reference pricing schemes with respect to the number of reference price countries and the pricing rule has not been studied extensively so far. Moreover, the effect of one country adopting a specific

[1] Also non-European countries such as Australia, Canada, Japan, South Korea, Mexico, New-Zealand, and Turkey apply external reference pricing (Toumi et al., 2013).

[2] Historically, reference countries have been chosen according to economic comparability and/or geographic proximity, but over the last years, a trend towards larger country baskets has evolved (Toumi et al., 2013).

scheme on the respective choices of other countries has not received much attention in the literature. Since reference pricing makes drug prices interdependent, it may also make different reference pricing regimes interdependent: One country applying external reference pricing may incentivize other countries to follow. Therefore external reference pricing may not only create price convergence but regulatory convergence as well.

Against this background, this paper explores the design of external reference pricing schemes in a three-country-framework. This framework allows analyzing different sets of reference countries and pricing rules. Also, it makes it possible to study the effect of reference pricing on third countries, especially their incentive also to introduce external reference pricing. This paper analyzes the choice of external reference pricing schemes in one country as well as its effect on welfare in the other countries, the manufacturer's export decision, and the incentives for the other countries to also adopt an external reference pricing scheme.

Given that the manufacturer sells to all three countries, the minimum price-rule yields the lowest drug price. As external reference pricing may increase the drug price in the reference country, it creates the incentive for the reference countries to also adopt external reference pricing. Thus external reference pricing results in regulatory convergence and a uniform price among all countries, i.e., price convergence. If the referencing country is sufficiently large, the manufacturer may not export to reference countries under the minimum price-rule. Then the average price-rule may safeguard exports to reference countries and generates a lower drug price in the referencing country.

The rest of the paper is organized as follows. In the next section, the model is presented. Section 3 studies the regulatory scenarios. Section 4 analyzes the choice of regulatory schemes in one country; section 5 studies its effect on welfare in the other countries. Section 6 studies the incentives for the other countries to also adopt an external reference pricing scheme. Section 7 analyzes the choice of external reference pricing schemes on the manufacturer's export decision. Section 8 concludes.

2 The Model

Consider an innovative firm selling a drug in three countries, $j = A, B, C$. Assume that the firm is located in a fourth country.

In all three countries, third-party payers cover drug costs partially. Consider that consumers pay a fraction γ_j, $\gamma_j \in (0, 1)$, of the drug price out-of-pocket (coinsurance). This is, drug copayment and thus the effective price for consumers is $c_j = \gamma_j p_j$. Third-party payers reimburse a fraction $\left(1 - \gamma_j\right) p_j$ of the drug price. Reimbursement and the role of third-party payers in financing the drug create the incentive for regulation to decrease public cost.

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 the drug obtains a net utility of

$$U(\theta_{ij}, c_j) = \theta_{ij} - \gamma_j p_j, \tag{1}$$

where θ_{ij} is a preference parameter, γ_j is the coinsurance rate, and p_j is the drug price in country j.

Consumers differ in the preference parameter θ, which may be interpreted as willingness to pay. Heterogeneity among consumers may stem from differences in the severity of the condition, prescription practices or insurance coverage (see e.g., Brekke, Holmas & Straume, 2011). Assume that the parameter θ is uniformly distributed over the interval $[0, \mu_j]$ in country $j = A, B, C$, where μ_A, $\mu_B \geq \mu_c = 1$. The parameter μ_j can be interpreted as the maximum willingness to pay for a given price, in the following referred to as market size. The total mass of consumers in all countries is one.

The marginal consumer in country j who is indifferent between buying the drug or not has a gross valuation $\widehat{\theta_j} = \gamma_j p_j$. Hence, demand in country j is given as $q_N = \frac{1}{\mu}\left(\mu - \gamma_j p_j\right)$.

In this set-up, there are two differences between countries: First, countries differ in maximum willingness to pay for a given price. Second, countries differ in demand elasticity (due to differences in coinsurance rates). Differences in μ_j and/or γ_j generate differences in drug prices, providing the incentive for governments to implement price caps based on the price in another country (external reference pricing).

Consider the following timing: In stage 1, the regulatory agency in country A chooses the external reference pricing scheme to minimize the drug price. In stage 2, the firm sets prices.

3 Regulatory Scenarios

3.1 Coinsurance

Consider first the case of coinsurance where the manufacturer may set the price freely in all countries. Variables under coinsurance are denoted by an asterisk.

The manufacturer sets country-specific prices p_j^* to maximize its profit

$$\pi = \sum_{j \in A,B,C} \frac{1}{\mu_j} \left(\mu_j - \gamma_j p_j^* \right) p_j^*. \tag{2}$$

The equilibrium price p_j in country j is

$$p_j^* = \frac{\mu_j}{2\gamma_j}. \tag{3}$$

The price p_j in country j increases in market size μ_j and decreases in the coinsurance rate γ_j. Thus, price differences between countries are driven by differences in market size μ_j and coinsurance rates γ_j.

The manufacturer's profit from selling in country j is

$$\pi_j^* = \frac{\mu_j}{4\gamma_j}. \tag{4}$$

3.2 External Reference Pricing

Consider now the case where the government in country A adopts external reference pricing. The following external reference pricing schemes are studied:

- One reference country (B), denoted as $1B$. This imposes a price cap $P_A^{1B} = p_B$.
- One reference country (C), denoted as $1C$. This imposes a price cap $P_A^{1C} = p_C$.
- Two reference countries, denoted as $2minj$. This imposes a price cap $P_A^{2min} = min\{p_B, p_C\}$.
- Two reference countries, denoted as $2avg$. This imposes a price cap $P_A^{2avg} = \frac{1}{2}p_B + \frac{1}{2}p_C$.

3.2.1 One Reference Country

Consider first that the government in country A sets a price cap based on the price in one country. For instance, Luxemburg only refers to the manufacturer's home country (Toumi et al., 2013). Two cases are possible; the price cap can be based on the drug price in country B (scheme $1B$) or the drug price in country C (scheme $1C$). The choice between the two reference countries is considered exogenous at this point.

Under scheme $1B$, the manufacturer sets prices to maximize

$$\begin{aligned} \pi^{1B} &= p_A^{1B}\frac{1}{\mu_A}\left(\mu_A-\gamma_A p_A^{1B}\right)+p_B^{1B}\frac{1}{\mu_B}\left(\mu_B-\gamma_B p_B^{1B}\right)+\left(1-\gamma_C p_C^{1B}\right)p_C^{1B} \\ & \text{s.t. } p_A^{1B}\le P_A^{1B}=p_B^{1B}. \end{aligned} \tag{5}$$

Equilibrium prices are

$$p_A^{1B}=P_A^{1B}=p_B^{1B}=\frac{\mu_A\mu_B}{\gamma_B\mu_A+\gamma_A\mu_B},\ p_C^{1B}=\frac{1}{2\gamma_C}. \tag{6}$$

The manufacturer's profit is

$$\pi^{1B}=\frac{\gamma_B\mu_A^2\mu_B}{\left(\gamma_A\mu_B+\gamma_B\mu_A\right)^2}+\frac{\gamma_A\mu_A\mu_B^2}{\left(\gamma_A\mu_B+\gamma_B\mu_A\right)^2}+\frac{1}{4\gamma_C}. \tag{7}$$

The imposed price cap P_A^{1B} is binding, i.e., $p_A^{1B}\le p_A^*$ if $\mu_A\ge\widehat{\mu_{A_{1B}}}=\frac{\gamma_A\mu_B}{\gamma_B}$.

Equilibrium existence requires that the manufacturer has no incentive to deviate from the proposed prices. A deviation to $\widetilde{p_A^{1B}}$, $\widetilde{p_B^{1B}}$ with $\widetilde{p_A^{1B}}<\widetilde{p_B^{1B}}$ would allow it to avoid the price cap based on the price in country B. However, this is not profitable, i.e., $\pi^{1B}-\pi\left(\widetilde{p_A^{1B}},\widetilde{p_B^{1B}}\right)>0$, see Appendix A.1.

Under scheme $1C$, the manufacturer sets prices to maximize

$$\begin{aligned} \pi^{1C} &= p_A^{1C}\frac{1}{\mu_A}\left(\mu_A-\gamma_A p_C^{1C}\right)+p_B^{1C}\frac{1}{\mu_B}\left(\mu_B-\gamma_B p_B^{1C}\right)+\left(1-\gamma_C p_C^{1C}\right)p_C^{1C} \\ & \text{s.t. } p_A^{1C}=P_A^{1C}\le p_C^{1C}. \end{aligned} \tag{8}$$

Equilibrium prices are

$$p_A^{1C}=P_A^{1C}=p_C^{1C}=\frac{\mu_A}{\gamma_C\mu_A+\gamma_A},\ p_B^{1C}=\frac{\mu_B}{2\gamma_B}. \tag{9}$$

The manufacturer's profit is

$$\pi^{1C}=\frac{\gamma_C\mu_A^2}{\left(\gamma_A+\gamma_C\mu_A\right)^2}+\frac{\mu_B}{4\gamma_B}+\frac{\gamma_A\mu_A}{\left(\gamma_A+\gamma_C\mu_A\right)^2}. \tag{10}$$

The imposed price cap P_A^{1C} is binding, i.e., $p_A^{1C}\le p_A^*$ if $\mu_A\ge\widehat{\mu_{A_{1C}}}=\frac{\gamma_A}{\gamma_C}$. Similarly, as under 1B, there is no incentive for the manufacturer to deviate to a strategy $\widetilde{p_A^{1C}}$, $\widetilde{p_B^{1C}}$

with $\widetilde{p_A^{1C}} < \widetilde{p_B^{1C}}$ to avoid the price P_A^{1C}, see Appendix A.1.

3.2.2 Two Reference Countries, Minimum Price

Consider now that the regulatory agency in country A sets a price cap based on the minimum price in countries B and C. For instance, Hungary, Italy, and Spain use the minimum price-rule (Toumi et al., 2013).

The manufacturer sets prices to maximize

$$\begin{aligned}\pi^{2minj} &= p_A^{2minj}\frac{1}{\mu_A}\left(\mu_A-\gamma_A p_A^{2minj}\right)+p_B^{2minj}\frac{1}{\mu_B}\left(\mu_B-\gamma_B p_B^{2minj}\right)\\ &\quad+\left(1-\gamma_C p_C^{2minj}\right)p_C^{2minj}\\ &\quad \text{s.t. } p_A^{2minj}\leq P_A^{2min}=min\{p_B^{2minj},p_C^{2minj}\}. \qquad (11)\end{aligned}$$

Based on differences in market size and coinsurance rates, three price vectors p_A^{2minj}, p_B^{2minj}, p_C^{2minj}, with $p_A^{2minj} = P_A^{2min} = min\{p_B^{2minj}, p_C^{2minj}\}$, are equilibrium outcomes. In two equilibria, the manufacturer is constrained in setting the price for country A and a second country, but may set the price freely in the third country: In equilibrium $2minB$, the price cap in A is based on the price in country B, which is lower than the (unconstrained) price in country C. In equilibrium $2minC$, the price cap in A is based on the price in country C, which is lower than the (unconstrained) price in country B. In equilibrium $2minBC$, the manufacturer is constrained in price setting in all three countries and sets a uniform price.

In equilibrium $2minB$, equilibrium prices are

$$p_A^{2minB}=P_A^{2minB}=p_B^{2minB}=\frac{\mu_A\mu_B}{\gamma_B\mu_A+\gamma_A\mu_B},\ p_C^{2minB}=\frac{1}{2\gamma_C}. \qquad (12)$$

The manufacturer's profit is

$$\pi^{2minB}=\frac{\gamma_B\mu_A^2\mu_B}{(\gamma_A\mu_B+\gamma_B\mu_A)^2}+\frac{\gamma_A\mu_A\mu_B^2}{(\gamma_A\mu_B+\gamma_B\mu_A)^2}+\frac{1}{4\gamma_C}.$$

The imposed price cap P_A^{2minB} is binding, i.e., $p_A^{2minB} \leq p_A^*$ if $\mu_A \geq \widehat{\mu_{A_{2minB}}} = \frac{\gamma_A\mu_B}{\gamma_B}$.

In equilibrium $2minC$, equilibrium prices are

$$p_A^{2minC}=P_A^{2minC}=p_C^{2minC}=\frac{\mu_A}{\gamma_C\mu_A+\gamma_A},\ p_B^{2minC}=\frac{\mu_B}{2\gamma_B}. \qquad (13)$$

The manufacturer's profit is

$$\pi^{2minC} = \frac{\gamma_C \mu_A^2}{(\gamma_A + \gamma_C \mu_A)^2} + \frac{\mu_B}{4\gamma_B} + \frac{\gamma_A \mu_A}{(\gamma_A + \gamma_C \mu_A)^2}. \tag{14}$$

The imposed price cap P_A^{2minC} is binding, i.e., $p_A^{2minC} \leq p_A^*$ if $\mu_A \geq \widehat{\mu_{A_{2minC}}} = \frac{\gamma_A}{\gamma_C}$. In equilibrium $2minBC$, the (uniform) equilibrium price is

$$p_A^{2minBC} = P_A^{2minBC} = p_B^{2minBC} = p_C^{2minBC} = \frac{3\mu_A \mu_B}{2(\gamma_A \mu_B + \gamma_B \mu_A + \gamma_C \mu_A \mu_B)}. \tag{15}$$

The manufacturer's profit is

$$\begin{aligned} \pi^{2minBC} = & \frac{3\mu_A\mu_B(2\gamma_B\mu_A - \gamma_A\mu_B + 2\gamma_C\mu_A\mu_B)}{4(\gamma_A\mu_B + \gamma_B\mu_A + \gamma_C\mu_A\mu_B)^2} \\ & + \frac{3\mu_A\mu_B(2\gamma_A\mu_B - \gamma_B\mu_A + 2\gamma_C\mu_A\mu_B)}{4(\gamma_A\mu_B + \gamma_B\mu_A + \gamma_C\mu_A\mu_B)^2} \\ & + \frac{3\mu_A\mu_B(2\gamma_A\mu_B + 2\gamma_B\mu_A - \gamma_C\mu_A\mu_B)}{4(\gamma_A\mu_B + \gamma_B\mu_A + \gamma_C\mu_A\mu_B)^2}. \end{aligned} \tag{16}$$

The imposed price cap P_A^{2minBC} is binding, i.e., $p_A^{2minBC} \leq p_A^*$ if $\mu_A \geq \widehat{\mu_{A_{2minBC}}} = 2\gamma_A \frac{\mu_B}{\gamma_B + \mu_B \gamma_C}$.

Under this rule, differences in market size and coinsurance rates determine whether the price cap is based on the price in one country, allowing the price in the third country to be set freely ($2minB$ or $2minC$) or whether this rule constrains price setting in all three countries and the manufacturer sets a uniform price ($2minBC$). Whether the minimum rule imposes a constraint on the prices in country A and one reference country as for $2minB$ or $2minC$ or whether it imposes a constraint on prices in all three countries depends on the deviations from the profit maximizing price in country A and the reference country (the country with the lower of both prices). When setting prices under the minimum price-rule, the manufacturer balances the loss in profit from a lower price in country A against the loss in profit from a lower price in the reference country. As the change in profit due to a deviation $+\lambda$ or $-\lambda$ from the profit-maximizing price (the price under coinsurance) increases exponentially in λ[3], it is not optimal to adjust the price in only one country, leaving the price in the other country unchanged. Instead, the manufacturer minimizes losses in profits across countries by reducing the price in

[3] The change in profit due to a price $(p^* - \lambda)$ is $\Delta\pi = \pi_j(p^*) - \pi_j(p^* - \lambda) = -\frac{\gamma_j}{\mu_j}\lambda^2$.

country A and increasing it in the reference country. If the manufacturer is constrained in price setting in all three countries, it changes the price in both reference countries as well. This implies that the minimum rule changes the drug price not only in country A but also in at least one of the other countries. As the change in profit from price changes depends on the market size and the coinsurance rate in the respective country and the manufacturer balances losses in profit across all markets, price changes in all countries affected depend on market sizes and coinsurance rates in all countries.

If countries B and C are rather different concerning market size, so are the profit-maximizing prices under coinsurance when price setting is free. A price cap based on the lower of both prices and the corresponding deviations from the profit-maximizing price in A and the reference country are small relative to the price in the third country. Then the price cap in A is based on the lower of both prices (price of the smaller country), and the manufacturer may set the price freely in the third country (the larger country). This is, the equilibrium outcome is $2minB$ or $2minC$, depending on which country is smaller and yields the lower price. For $\mu_B \leq \underline{\mu_B} = \frac{\gamma_B}{2\gamma_C}$, the price cap is based on the price in country B and the price in country C is the same as under coinsurance. For $\mu_B \geq \overline{\mu_B} = \frac{2\gamma_B}{\gamma_C}$, the price cap is based on the price in country C and the price in country B is the same as under coinsurance.

If countries B and C are rather similar in market size, two cases can be distinguished: If the market size in country A is rather small relative to the market size in B and C, i.e., all three countries are rather similar, the deviations from the profit maximizing price in the reference country are small and do not affect the price in the third country. Then the manufacturer may set the price freely in one country (the larger country) and the price cap in A is based on the lower of the prices in countries B and C (price of the smaller country). This is, the equilibrium outcome is $2minB$ or $2minC$. If the market size in country A is rather large relative to the market size in B and C, the deviations from the profit maximizing price in country A and the reference country are too large to not affect the price for the third country. In this case, the minimum rule constrains the manufacturer in all three countries. A failure to take the constraint in the third country into account would create an inconsistent price ranking. The equilibrium outcome is $2minBC$.

This is, depending on market size, three equilibrium outcomes are possible under the minimum price-rule: For $\mu_B \leq \underline{\mu_B} = \frac{\gamma_B}{2\gamma_C}$ or $\underline{\mu_B} \leq \mu_B \leq \widehat{\mu_{B_{p_B=p_C}}} = \frac{\gamma_B}{\gamma_C}$ and $\mu_A \leq \widehat{\mu_{A_{p_B^{2minB}=p_C^{2minB}}}} = \frac{\gamma_A \mu_B}{2\gamma_C \mu_B - \gamma_B}$, the equilibrium outcome is $2minB$.
For $\widehat{\mu_{B_{p_B=p_C}}} \leq \mu_B \leq \overline{\mu_B} = \frac{2\gamma_B}{\gamma_C}$ and $\mu_A \leq \widehat{\mu_{A_{p_B^{2minC}=p_C^{2minC}}}} = \frac{\gamma_A \mu_B}{2\gamma_B - \gamma_C \mu_B}$ or $\mu_B \geq \overline{\mu_B}$, the

equilibrium outcome is $2minC$. For $\underline{\mu_B} \leq \mu_B \leq \mu_{\widehat{B_{p_B=p_C}}}$ and $\mu_A > \mu_{\widehat{A_{p_B^{2minB}=p_C^{2minB}}}}$ or $\mu_{\widehat{B_{p_B=p_C}}} \leq \mu_B \leq \overline{\mu_B}$ and $\mu_A > \mu_{\widehat{A_{p_B^{2minC}=p_C^{2minC}}}}$, the equilibrium outcome is $2minBC$.

Figure 1 illustrates the equilibrium under the minimum price-rule for identical coinsurance rates in all three countries (panel 1) and the effect of an increase in the coinsurance rate in one country on equilibrium outcomes (panels 2 - 4). In all four panels, the equilibrium outcomes under the minimum price-rule are depicted as a function of market sizes in countries A and B. Four areas can be distinguished in all four panels: A^*: For a relatively small market size in country A, the price cap under minimum price-rule is not binding and coinsurance is applied. $2minB$: If the market size in A is sufficiently large and for small to intermediate market sizes in B, the price cap under the minimum price-rule is binding and the equilibrium outcome is $2minB$. $2minC$: If the market sizes in A and in B are sufficiently large, the equilibrium outcome is $2minC$. $2minBC$: If the market size in A is sufficiently large and the market size in B is intermediate, the equilibrium outcome is $2minBC$ with a uniform price.

Panel 2 (top right) illustrates the case of an increase in the coinsurance rate in country A. Compared to the first panel, a higher market size in country A is needed for the price cap under the minimum price-rule to be binding. The equilibrium price under coinsurance decreases in the coinsurance rate, so if consumers have to pay a larger fraction of the price out-of-pocket, the higher price elasticity may be seen as a substitute to direct price regulation. Also, the other equilibrium areas are shifted to the right compared to panel 1. Panel 3 (bottom left) depicts an increase in the coinsurance rate in country B. Due to the increase in the coinsurance rate in B and decrease of the price in country B (both the price in B under coinsurance and the price in B under $2minB$ decrease in γ_B), the price cap under the minimum price-rule is now binding for relatively small market sizes in countries A and B, while it is not binding under a lower coinsurance rate and coinsurance is applied (panel 1). The increase in the coinsurance rate and the corresponding price decrease make country B a more attractive reference price country. The other equilibria are shifted upwards, so other equilibrium outcomes are favorable only for a larger market size in B. Panel 4 (bottom right) illustrates the case of an increase in the coinsurance rate in country C, which is symmetric to the case of an increase in the coinsurance rate in country B.

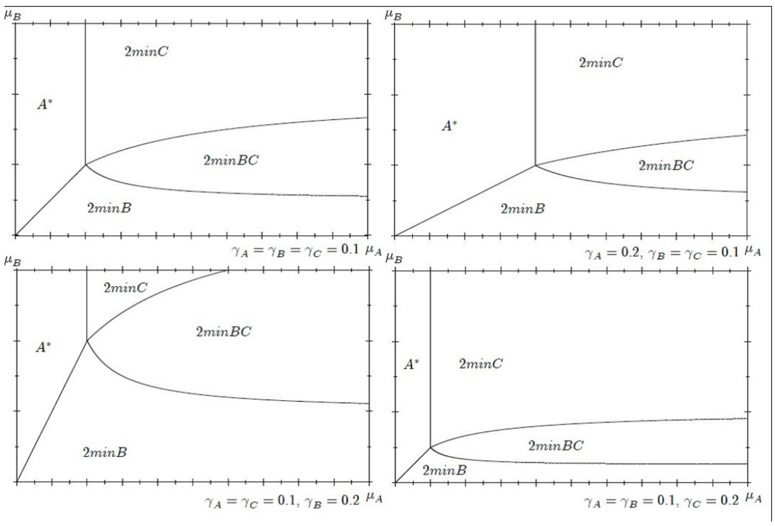

Figure 1: Equilibrium outcomes under the minimum price-rule.

Equilibrium existence requires that the manufacturer has no incentive to deviate from the proposed prices. Under the outcome $2minB$, a deviation to $\widetilde{p_A^{2minB}}$, $\widetilde{p_B^{2minB}}$ with $\widetilde{p_A^{2minB}} < \widetilde{p_B^{2minB}}$ would allow it to avoid the price cap. However, this is not profitable, i.e., $\pi^{2minB} - \pi\left(\widetilde{p_A^{2minB}}, \widetilde{p_B^{2minB}}\right) > 0$, see Appendix A.1. Similar for $2minC$, a deviation to $\widetilde{p_A^{2minC}}$, $\widetilde{p_B^{2minC}}$ with $\widetilde{p_A^{2minC}} < \widetilde{p_B^{2minC}}$ to avoid the price cap in country A is not profitable. Under $2minBC$, a deviation to $\widetilde{p_A^{2minBC}}$, $\widetilde{p_B^{2minBC}}$, $\widetilde{p_C^{2minBC}}$ with $\widetilde{p_A^{2minB}} < \widetilde{p_B^{2minB}} = \widetilde{p_C^{2minBC}}$.

3.2.3 Two Reference Countries, Average Price

Consider now that the regulatory agency in country A sets a price cap based on the average price in countries B and C (scheme $2avg$).

For example, in Austria, Denmark, and the Netherlands, the average price-rule is applied (Toumi et al., 2013).

The manufacturer sets prices to maximize

$$\begin{aligned} \pi^{2avg} &= p_A^{2avg} \frac{1}{\mu_A}\left(\mu_A - \gamma_A p_A^{2avg}\right) + p_B^{2avg} \frac{1}{\mu_B}\left(\mu_B - \gamma_B p_B^{2avg}\right) + \left(1 - \gamma_C p_C^{2avg}\right) p_C^{2avg} \\ & \text{s.t. } p_A^{avg} \leq P_A^{2min} = \frac{1}{2} p_B^{2avg} + \frac{1}{2} p_C^{2avg} \end{aligned} \tag{17}$$

Equilibrium prices are

$$\begin{aligned}
p_A^{2avg} &= \frac{3\mu_A\left(\gamma_B+\gamma_C\mu_B\right)}{2\left(\gamma_A\gamma_B+\gamma_A\gamma_C\mu_B+4\gamma_B\gamma_C\mu_A\right)}\\
p_B^{2avg} &= \frac{3\gamma_C\mu_A\mu_B}{\gamma_A\gamma_B+\gamma_A\gamma_C\mu_B+4\gamma_B\gamma_C\mu_A},\\
p_C^{2avg} &= \frac{3\gamma_B\mu_A}{\gamma_A\gamma_B+\gamma_A\gamma_C\mu_B+4\gamma_B\gamma_C\mu_A}. \qquad (18)
\end{aligned}$$

The manufacturer's profit is

$$\begin{aligned}
\pi^{2avg} &= \frac{3\mu_A\left(\gamma_B+\mu_B\gamma_C\right)\left(8\gamma_B\gamma_C\mu_A-\gamma_A\gamma_B-\gamma_A\gamma_C\mu_B\right)}{4\left(\gamma_A\gamma_B+\gamma_A\gamma_C\mu_B+4\gamma_B\gamma_C\mu_A\right)^2}\\
&\quad+\frac{3\gamma_C\mu_A\mu_B\left(\gamma_A\gamma_B+\gamma_A\gamma_C\mu_B+\gamma_B\gamma_C\mu_A\right)}{\left(\gamma_A\gamma_B+\gamma_A\gamma_C\mu_B+4\gamma_B\gamma_C\mu_A\right)^2}\\
&\quad+\frac{3\gamma_B\mu_A\left(\gamma_A\gamma_B+\gamma_A\gamma_C\mu_B+\gamma_B\gamma_C\mu_A\right)}{\left(\gamma_A\gamma_B+\gamma_A\gamma_C\mu_B+4\gamma_B\gamma_C\mu_A\right)^2}. \qquad (19)
\end{aligned}$$

The imposed price cap P_A^{2avg} is binding, i.e., $p_A^{2avg} \leq p_A^*$ if $\mu_A \geq \widehat{\mu_{A_{2avg}}} = \frac{\gamma_A\gamma_B+\gamma_A\gamma_C\mu_B}{2\gamma_B\gamma_C}$.

Equilibrium existence requires that the manufacturer has no incentive to deviate from the proposed prices. Under the average price-rule, a deviation to $\widetilde{p_A^{2avg}}$, $\widetilde{p_B^{2avg}}$, $\widetilde{p_C^{2avg}}$ with $\widetilde{p_B^{2avg}} < \frac{1}{2}\widetilde{p_B^{2avg}} + \frac{1}{2}\widetilde{p_C^{2avg}}$ would allow it to avoid the price cap. However, this is not profitable, i.e., $\pi^{2avg} - \pi\left(\widetilde{p_A^{2avg}}, \widetilde{p_B^{2avg}}, \widetilde{p_C^{2avg}}\right) > 0$, see Appendix A.1.

4 Choice of Regulatory Scheme

Consider now the choice of the regulatory schemes by the regulatory agency with the aim to minimize the drug price. Welfare in country A, given as profit in country A plus consumer surplus less third party payer expenditure ($W_A = \pi_A + CS_A - E_A$), decreases in the drug price[4]. Minimizing the drug price is thus equivalent to maximizing welfare.

External reference pricing lowers the drug price compared to coinsurance if market size in country A (relative to the coinsurance rate) is sufficiently large and the price cap imposed by external reference pricing is binding.

Choosing only one reference country, i.e., scheme $1B$ or $1C$, is not optimal as the government in country A foregoes using information on a lower price and accordingly

[4]Throughout this paper, profit generated in country j is included in the welfare of country j, e.g. because of a subsidiary of the manufacturer located in j who supplies the market. Results do not change, however, if local profits are not considered in country j at all, as welfare, given as consumer surplus less third-party payer expenditure also decreases in the drug price.

the possibility of choosing a lower price cap. Schemes $1B$ and $1C$ yield the same drug price as schemes $2minB$ and $2minC$, but for the parameter set where the minimum rule generates a uniform price across all three countries, schemes $1B$ and $1C$ yield a higher drug price than the minimum rule. The minimum price-rule allows the regulator to exert a stronger restriction on the manufacturer's price setting and to enforce a uniform price.

Consider in the following that the government in country A chooses two reference countries. If country B and C are sufficiently different, the minimum price-rule generates a lower price than the average price-rule, as using the higher of both prices at all does not make sense. Moreover, the link between prices in country A and the country with the lower price is stronger under the minimum price-rule: Whereas under the average price-rule price changes in the reference countries are transmitted to country A only by one 50% each, the minimum price-rule enforces a direct one-to-one link between prices in the reference country and the referencing country A.

If country B and C are rather similar and the market size in country A is rather small relative to the market size in B and C, i.e., all three countries are rather similar, the minimum price-rule yields a lower price as the manufacturer makes higher price concessions in the reference country and country A in order to keep the price in the third country free. The average price-rule, on the contrary, imposes restrictions on the manufacturer's price setting in all three countries. If the market size in country A is rather large relative to the market size in B and C, both the minimum price-rule and the average price-rule impose restrictions on the manufacturer's price setting in all three countries. In this case, the minimum price-rule yields a lower price as it enforces a direct one-to-one link between prices in all countries.

Proposition 1 summarizes the choice of regulatory schemes in country A:

Proposition 1 *The government in country A chooses two reference countries and the minimum price-rule to minimize the drug price.*

5 Effect on Drug Prices in Reference Countries

This section studies the effect of external reference pricing in country A on drug prices and welfare in countries B and C.

Welfare in country B and C is given as

$$\begin{aligned} W_B &= CS_B - E_B + \pi_B = \frac{\mu_B^2 - \gamma_B^2 p_B^2}{2\mu_B} \\ W_C &= CS_C - E_C + \pi_C = \frac{1 - \gamma_C^2 p_C^2}{2\mu_C}. \end{aligned} \tag{20}$$

As welfare decreases in the price, higher prices decrease welfare.

Country A implements the minimum price-rule to minimize the drug price in country A. If the equilibrium outcome is $2minB$, this increases the drug price in country B compared to coinsurance while leaving the drug price in country C unchanged, i.e., $p_B^{2minB} > p_B^*$, $p_C^{2minB} = p_C^*$. Similarly, under $2minC$, the drug price in country C is higher than under coinsurance while the drug price in country B is not affected, i.e., $p_C^{2minC} > p_C^*$, $p_B^{2minC} = p_B^*$. Also, under $2minBC$, drug prices in countries B and C are higher than under coinsurance.

Proposition 2 summarizes the effect of the choice of regulatory scheme in country A on drug prices in countries B and C:

Proposition 2 *If country A adopts the minimum price-rule, drug prices in countries B and C are higher than under free pricing in country A.*

6 Mutual Referencing

Consider now cases where also countries B and C may adopt external reference pricing schemes. In countries B and C, the increase in drug prices under external reference pricing in country A may create the incentive to apply also an external reference pricing scheme.

6.1 One Reference Country

If countries use one reference country, six cases are possible.

i) Single referencing: One country, e.g., A references to one country, e.g., B, the other two countries (B, C) do not apply external reference pricing.

ii) Mutual referencing: One country, e.g., A references to one country, e.g., B, which references back to A. Country C does not apply external reference pricing.

iii) Circular referencing: One country, e.g., A, references to one country, e.g., B, which references to C, which references to country A.

iv) Incomplete circular referencing: One country, e.g., A, references to one country, e.g., B, which references to C. Country C does not apply external reference pricing.

v) Mutual referencing and referencing from the third country: One country, e.g., A references to one country, e.g., B, which references back to A. Country C also references to country B.

vi) Joint referencing: One country, e.g., A references to one country, e.g., B. Country C also references to country B. Country B does not apply external reference pricing.

While cases i) and ii) are equivalent to the case in 3.2.1, cases iii) to vi) result in the manufacturer setting a uniform price p in all three countries. In this case, the manufacturer sets a uniform price $p = \frac{3\mu_A\mu_B}{2(\gamma_A\mu_B+\gamma_B\mu_A+\gamma_C\mu_A\mu_B)}$ in all three countries.

If A refers to the price in country B (or C), there is no incentive or disincentive for country B (or C) to refer back to A, as prices are identical in both countries.

But if A refers to the price in B, there is an incentive for C to also refer to the price in A or B, as it lowers the price in C, i.e., $p < p_C^{1B}$ for $\mu_A < \widehat{\mu_{A_{p_B^{2minB}=p_C^{2minB}}}}$. Similarly, if A refers to the price in C, there is an incentive for B to also refer to the price in A or C to lower the price, i.e., $p < p_B^{1C}$ for $\mu_A < \widehat{\mu_{A_{p_B^{2minC}=p_C^{2minC}}}}$.

6.2 Two Reference Countries, Minimum Price

If countries use two reference countries and the minimum price-rule, three cases are possible.

i) Only one country, e.g., A, adopts the minimum price-rule and references to the prices in countries B and C.

ii) Two countries, e.g., A and B adopt the minimum price-rule and reference to the prices in countries B and C, A and C, respectively.

iii) All countries adopt the minimum price-rule.

Case i) and ii) are equivalent to the case in 3.2.2, case iii) results in a uniform price p in all three countries.

If A adopts the minimum price-rule, there is no incentive for the country with the lower price (B or C) to also adopt the minimum price-rule, as the outcome in case i) and ii) is the same. But for the third country, e.g., C if $\mu_B < \widehat{\mu_{B_{p_B=p_C}}}$, there is an incentive to also adopt the minimum price-rule, as it results in a lower drug price ($p < p_C^{2minB}$ for $\mu_A < \widehat{\mu_{A_{p_B^{2minB}=p_C^{2minB}}}}$).

6.3 Two Reference Countries, Average Price

If countries use two reference countries and the average price-rule, three cases are possible.

i) Only country one country, e.g., A adopts the average price-rule and references to the prices in countries B and C.

ii) Two countries, e.g., A and B, adopt the average price-rule and reference to the prices in countries B and C, A and C, respectively.

iii) All countries adopt the average price-rule.

Case i) is equivalent to the case in 3.2.2, cases ii) and iii) result in a uniform price p in all three countries.

If country A adopts the average price-rule, there is an incentive to also adopt the average price rule for the country with the larger market size and accordingly, the higher drug price, as it results in a lower drug price, i.e., $p < p_B^{2avg}$ for $\mu_B > \mu_{\widehat{B_{p_B=p_C}}}$, $p < p_C^{2avg}$ for $\mu_B < \mu_{\widehat{B_{p_B=p_C}}}$).

Independent of the external reference pricing scheme chosen by A, there is an incentive for the third country or the country with the higher price also to adopt an external reference pricing scheme. In all cases the outcome is a uniform price, implying price convergence across all countries.

If country A adopts the minimum price-rule, a switch to uniform pricing increases the drug price in A, i.e., $p > p_A^{2minB}$, $p > p_A^{2minC}$. This is, regulatory convergence does not generate downward price convergence. If country A adopted the average price-rule, a switch to uniform pricing would decrease the drug price in A, i.e., $p < p_A^{2avg}$.

Proposition 3 summarizes the incentive for the other countries to also adopt an external reference pricing scheme:

Proposition 3 *If country A adopts an external reference pricing scheme, there is an incentive for the third country or country with the higher drug price to also adopt external reference pricing. If all countries adopt an external reference pricing scheme, the manufacturer sets a uniform drug price for all three countries.*

If country A applies any external reference scheme, the other countries also have an incentive to apply an external reference pricing scheme. The likely outcome is a uniform price in all three countries.

Compared to the scenario with coinsurance, a uniform price increases the welfare in country A if the market size in country A is sufficiently large, i.e., $\Delta W_A = W_A^* - W_A^p > 0$ if $\mu_A > \mu_{\widehat{A_{2minBC}}}$. Note that $\mu_{\widehat{A_{2minBC}}} > \mu_{\widehat{A_{2minB}}}$, that is, country A may apply an external reference pricing scheme which is binding, but due to the incentive for other countries to apply external reference pricing schemes as well, welfare (and consequently the drug price) in country A is lower than under no regulation.

In country B, the uniform price increases welfare if the market size in country A is sufficiently small or if the market size in country B is sufficiently large, i.e., $\Delta W_B = W_B^* - W_B^p > 0$ if $\mu_B < \overline{\overline{\mu_B}} \wedge \mu_A < \widehat{\mu_{A_{p_B^{2minC}=p_C^{2minC}}}} \vee \mu_B > \overline{\overline{\mu_B}}$. In both cases, the uniform price is lower than the price under coinsurance. A sufficiently small market size in country A decreases the uniform price (which increases in the market size of country A), a sufficiently large market size in country B increases the price under coinsurance by more than the uniform price. In country C, the uniform price increases welfare if the market size in country A is sufficiently small or if the market size in country B (relative to the market size in country C) is sufficiently small, i.e., $\Delta W_C = W_C^* - W_C^p > 0$ if $\mu_B > \underline{\underline{\mu_B}} \wedge \mu_A < \widehat{\mu_{A_{p_B^{2minB}=p_C^{2minB}}}} \vee \mu_B < \underline{\underline{\mu_B}}$. In both cases, the uniform price is lower than the price under coinsurance. Both a sufficiently small market size in country A and a sufficiently small market size in country B decrease the uniform price (which increases in the market size of country A and market size of country B).

For all three countries, these effects offset each other and global welfare increases i.e., $W^p - W^* > 0$.

Proposition 4 summarizes the welfare effect of uniform pricing.

Proposition 4 *If other countries also apply external reference pricing and a uniform price is the outcome, global welfare increases.*

7 Endogenous Export Decision

Consider now that the firm may adjust its export decision to the choice of regulatory schemes in country A. In particular, it may refrain from exporting to one of the countries, if a low price may spill over to a high price country. Consider in the following that country A applies the minimum price-rule, as it generates the lowest drug price. Export decisions under all external reference pricing schemes can be found in Appendix A.5.

If the government in country A applies the minimum price-rule and $2minB$ is the equilibrium outcome, the price cap in country A is based on the price in country B, which is lower than the price in country C. If the manufacturer decides not to export to B (and the price cap is based on the price in country C instead), it can avoid the low price cap at the cost of foregoing profits from selling in country B and not being able to set the price in country C freely. Moreover, the resulting price cap based on the price in country C is less restrictive. The manufacturer does not export to country B if the profit from selling to country A and C under the scheme $1C$ is higher than the profit from selling to all three countries under the scheme $2minB$, i.e., $\pi_A^{1C} + \pi_C^{1C} - \pi^{2minB} > 0$, which is the case if $\mu_A > \widetilde{\mu_{A_{2minB,1C}}} = \frac{\gamma_A\left(\gamma_B+\gamma_C\mu_B+\sqrt{(\gamma_B-\gamma_C\mu_B)(\gamma_B+15\gamma_C\mu_B)}\right)}{2\gamma_C(3\gamma_B-4\gamma_C\mu_B)}$ and $\mu_B < \widetilde{\mu_{B_{2minB,1C}}} = \frac{3\gamma_B}{4\gamma_C}$. Similarly, if $2minC$ is the equilibrium outcome under the minimum price-rule, the manufacturer may decide not to export to C (with the price cap being based on the price in country B instead) to avoid a low price cap in country A. The manufacturer does not export to country C if the profit from selling to country A and B under the scheme $1B$ is higher than the profit from selling to all three countries under the scheme $2minC$, i.e., $\pi_A^{1B} + \pi_B^{1B} - \pi^{2minC} > 0$, which is the case if $\mu_A > \widetilde{\mu_{A_{2minC,1B}}} = \frac{\gamma_A\mu_B\left(\gamma_B+\mu_B\gamma_C+\sqrt{(\mu_B\gamma_C-\gamma_B)(15\gamma_B+\mu_B\gamma_C)}\right)}{2\gamma_B(3\mu_B\gamma_C-4\gamma_B)}$ and $\mu_B > \widetilde{\mu_{B_{2minC,1B}}} = \frac{4\gamma_B}{3\gamma_C}$. If $2minBC$ is the equilibrium outcome under the minimum price-rule, the manufacturer does not export to country B if $\pi_A^{1C} + \pi_C^{1C} - \pi^{2minBC} > 0$, which is the case if $\mu_A > \widetilde{\mu_{A_{2minBC,1C}}} = \frac{5\gamma_A\mu_B}{4\gamma_B-5\mu_B\gamma_C}$ and $\mu_B < \widetilde{\mu_{B_{2minBC,1C}}} = \frac{4\gamma_B}{5\gamma_C}$. It does not export to country C if $\pi_A^{1B} + \pi_B^{1B} - \pi^{2minBC} > 0$, which is the case if $\mu_A > \widetilde{\mu_{A_{2minBC,1B}}} = \frac{5\gamma_A\mu_B}{4\mu_B\gamma_C-5\gamma_B}$ and $\mu_B > \widetilde{\mu_{B_{2minBC,1B}}} = \frac{5\gamma_B}{4\gamma_C}$, and it does not export to neither country if $\pi_A^* - \pi^{2minBC} > 0$ if $\mu_A > \widetilde{\mu_{A_{2minBC,A^*}}} = \frac{8\gamma_A\mu_B}{\gamma_B+\mu_B\gamma_C}$. The manufacturer decides not to export if the distortions in country A from reducing the price are higher than the loss in profit from not selling to one country and accepting a price constraint and hence a distortion in the third country. As the loss in profit from deviations from the optimal price increase in market size, the manufacturer decides not to export if the market size in country A is rather large. This implies that the minimum price-rule is not feasible for all combinations of market size, as Figure 2 shows. Figure 2 depicts equilibrium outcomes under the minimum price-rule for different market sizes in A and B and identical coinsurance rates in all three countries when the export decision is endogenous. If the market size in country A is sufficiently large and the market in B is sufficiently small, the firm may refrain from exporting to B. As a result, the minimum price-rule turns into the rule $1C$. Similarly, if the market sizes in countries A and B are large, the firm refrains from supplying country C under the minimum price-rule, so that the resulting reference price rule is $1B$ instead. In both cases, $1B$ and $1C$ result in a higher price than the equilibrium outcomes $2minB$ and $2minC$ would have.

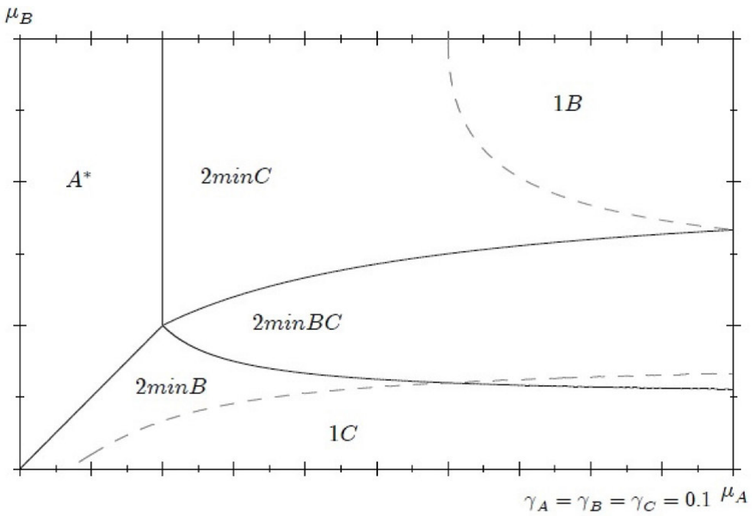

Figure 2: Minimum price-rule and endogeneous export decision.

If the government in country A applied the average price-rule instead, the manufacturer would not export to country B and accept a price cap based on the price in country C instead if $\pi_A^{1C} + \pi_C^{1C} - \pi^{2avg} > 0$ which is the case if $\mu_A > \widetilde{\mu_{A_{avg,1C}}} = \frac{5\gamma_A(\gamma_B+\gamma_C\mu_B)}{\gamma_C(7\gamma_B-9\mu_B\gamma_C)}$ and $\mu_B < \widetilde{\mu_{B_{avg,1C}}} = \frac{7\gamma_B}{9\gamma_C}$. Similarly, it would not export to country C and accept a price cap based on the price in country B if $\pi_A^{1B} + \pi_B^{1B} - \pi^{2avg} > 0$ which is the case if $\mu_A > \widetilde{\mu_{A_{avg,1B}}} = \frac{5\gamma_A\left(\gamma_C\mu_B^2+\gamma_B\mu_B\right)}{\gamma_B(7\gamma_C\mu_B-9\gamma_B)}$ and $\mu_B > \widetilde{\mu_{B_{avg,1B}}} = \frac{9\gamma_B}{7\gamma_C}$. As $\widetilde{\mu_{A_{avg,1C}}} > \widetilde{\mu_{A_{2minB,1C}}}$ and $\widetilde{\mu_{A_{avg,1B}}} > \widetilde{\mu_{A_{2minC,1B}}}$ as well as $p_A^{2avg} < p_A^{1C}$ and $p_A^{2avg} < p_A^{1B}$, the government in A could achieve a lower price by the average price-rule than by the minimum price-rule if it takes the export decision of the manufacturer into account, as illustrated in Figure 3.

Figure 3 is similar to Figure 2, but considers the option of the government in country A to apply the average price-rule instead. The average price-rule may buffer the risk stemming from country B not being supplied under the rule $2minB$ and endogenous export decisions. If applying the rule $2minB$ results in the risk of country B not being supplied (as in Figure 2), country A may switch to the average price-rule if the market size in A is sufficiently small. The price under the average price-rule is lower than under the resulting outcome $1C$.

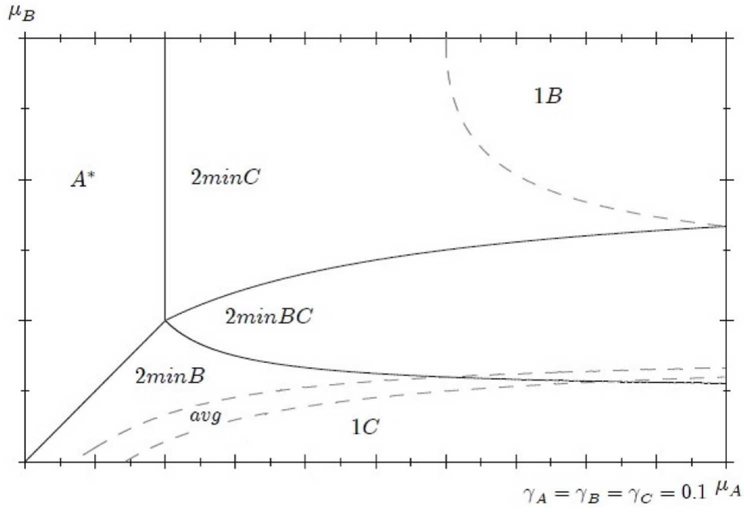

Figure 3: Minimum price-rule, average price-rule, and endogeneous export decision.

At the same time, the adoption of the average price-rule safeguards exports to country B, respectively country C.

Proposition 5 summarizes the effect of an endogenous export decision on the choice of the external reference pricing scheme:

Proposition 5 *If country A adopts the minimum price-rule, the manufacturer does not export to country B (C) if* $\mu_A > \mu_{\widetilde{A_{2minB,1C}}}$ $(\mu_A > \mu_{\widetilde{A_{2minC,1B}}})$*. For* $\mu_{\widetilde{A_{2minB,1C}}} \leq \mu_A \leq \mu_{\widetilde{A_{avg,1C}}}$ $(\mu_{\widetilde{A_{2minC,1B}}} \leq \mu_A \leq \mu_{\widetilde{A_{avg,1B}}})$ *the average price-rule yields a lower drug price than the minimum price-rule.*

8 Conclusion

This paper has studied the design of external reference pricing schemes, in particular, the choice of reference countries and pricing rules, in a three-country-framework. Given that the manufacturer sells to all three countries, referencing to two countries and adopting minimum price-rule generates the lowest drug price. Since external reference pricing lowers drug prices, it increases welfare in referencing countries.

At the same time, it increases drug prices in the reference countries, creating the incentive for other countries to also adopt external reference pricing. Thus, external reference pricing results in regulatory convergence and a uniform price among all countries, i.e., price convergence. External reference pricing by other countries does not generate downward price convergence, as it increases the price in country A.

If the market size in the country that applies reference pricing is sufficiently large, external reference pricing may prevent the manufacturer to supply the reference countries. Therefore, external reference pricing may induce substantial distortions in drug availability in third countries. Then the average price-rule may safeguard exports to reference countries and generate a lower drug price in the referencing country.

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Appendix

A.1 Regulatory Scenarios

External Reference Pricing Scheme 1B

Binding price cap P_A^{1B}: $p_A^{1B} - p_A^* = -\frac{1}{2\gamma_A}\frac{\mu_A(\mu_A\gamma_B - \gamma_A\mu_B)}{\gamma_A\mu_B + \mu_A\gamma_B} \leq 0$ if $\mu_A \geq \widehat{\mu_{A_{1B}}} = \frac{\gamma_A\mu_B}{\gamma_B}$.
Equilibrium existence: Consider the pricing strategy $\widetilde{p_A^{1B}} = \widetilde{p_B^{1B}} - \varepsilon$, which allows the manufacturer to avoid the price cap P_A^{1B}. The manufacturer's profit is maximized for $\widetilde{p_B^{1B}} = \frac{\mu_A\mu_B + \varepsilon\gamma_A\mu_B}{\gamma_A\mu_B + \mu_A\gamma_B}$, $\widetilde{p_A^{1B}} = \widetilde{p_B^{1B}} - \varepsilon = \frac{\mu_A(\mu_B - \varepsilon\gamma_B)}{\gamma_A\mu_B + \mu_A\gamma_B}$. The profit for this pricing strategy is $\pi\left(\widetilde{p_A^{1B}}, \widetilde{p_B^{1B}}, p_C\right) = \frac{\gamma_B\mu_A(\mu_A + \varepsilon\gamma_A)(\mu_B - \varepsilon\gamma_B)}{(\gamma_A\mu_B + \mu_A\gamma_B)^2} + \frac{\gamma_A(\mu_A\mu_B + \varepsilon\gamma_A\mu_B)(\mu_B - \varepsilon\gamma_B)}{(\gamma_A\mu_B + \mu_A\gamma_B)^2} + \frac{1}{4\gamma_C}$, with
$\pi^{1B}\left(p_A^{1B}, p_B^{1B}, p_C^{1B}\right) - \pi\left(\widetilde{p_A^{1B}}, \widetilde{p_B^{1B}}, \widetilde{p_C^{1B}}\right) = \frac{\varepsilon(\mu_A\gamma_B - \gamma_A\mu_B + \varepsilon\gamma_A\gamma_B)}{\gamma_A\mu_B + \mu_A\gamma_B} > 0$, if
$\mu_A > \widehat{\mu_{A_{\widetilde{1B}}}} = \frac{(\gamma_A\mu_B - \varepsilon\gamma_A\gamma_B)}{\gamma_B}$. Note that $\widehat{\mu_{A_{\widetilde{1B}}}} < \widehat{\mu_{A_{1B}}}$.

External Reference Pricing Scheme 1C

Binding price cap P_A^{1C}: $p_A^{1C} - p_A^* = -\frac{1}{2\gamma_A}\frac{\mu_A(\mu_A\gamma_C - \gamma_A)}{\gamma_A + \mu_A\gamma_C} \leq 0$ if $\mu_A \geq \widehat{\mu_{A_{1C}}} = \frac{\gamma_A}{\gamma_C}$.
Equilibrium existence: Consider the pricing strategy $\widetilde{p_A^{1C}} = \widetilde{p_C^{1C}} - \varepsilon$, which allows the manufacturer to avoid the price cap P_A^{1C}. The manufacturer's profit is maximized for $\widetilde{p_C^{1B}} = \frac{(\mu_A + \varepsilon\gamma_A)}{\gamma_A + \mu_A\gamma_C}$, $\widetilde{p_A^{2minB}} = \widetilde{p_B^{2minB}} - \varepsilon = \frac{\mu_A(1 - \varepsilon\gamma_C)}{\gamma_A + \mu_A\gamma_C}$. The profit for this pricing strategy is $\pi\left(\widetilde{p_A^{1C}}, p_B, \widetilde{p_C^{1C}}\right) = \frac{\gamma_C\mu_A(\mu_A + \varepsilon\gamma_A)(1 - \varepsilon\gamma_C)}{(\gamma_A + \gamma_C\mu_A)^2} + \frac{\gamma_A(\mu_A + \varepsilon\gamma_A)(1 - \varepsilon\gamma_C)}{(\gamma_A + \gamma_C\mu_A)^2} + \frac{\mu_B}{4\gamma_B}$, with
$\pi^{2minB}\left(p_A^{2minB}, p_B^{2minB}, p_C^{2minB}\right) - \pi\left(\widetilde{p_A^{2minB}}, \widetilde{p_B^{2minB}}, \widetilde{p_C^{2minB}}\right) = \frac{\varepsilon(\mu_A\gamma_C - \gamma_A + \varepsilon\gamma_A\gamma_C)}{\gamma_A + \gamma_C\mu_A} > 0$,
if $\mu_A > \widehat{\mu_{A_{\widetilde{1C}}}} = \frac{(\gamma_A - \varepsilon\gamma_A\gamma_C)}{\gamma_C}$. Note that $\widehat{\mu_{A_{\widetilde{1C}}}} < \widehat{\mu_{A_{1C}}}$.

External Reference Pricing Scheme 2min

Binding price cap P_A^{2minB}: $p_A^{2minB} - p_A^* = -\frac{\mu_A(\mu_A\gamma_B - \gamma_A\mu_B)}{2\gamma_A(\gamma_A\mu_B + \mu_A\gamma_B)} \leq 0$ if
$\mu_A \geq \widehat{\mu_{A_{2minB}}} = \frac{\gamma_A\mu_B}{\gamma_B}$.
Binding price cap P_A^{2minC}: $p_A^{2minC} - p_A^* = -\frac{\mu_A(\mu_A\gamma_C - \gamma_A)}{2\gamma_A(\gamma_A + \mu_A\gamma_C)} \leq 0$ if $\mu_A \geq \widehat{\mu_{A_{2minC}}} = \frac{\gamma_A}{\gamma_C}$.
Binding price cap P_A^{2minBC}: $p_A^{2minBC} - p_A^* = -\frac{1}{2\gamma_A}\frac{\mu_A(\mu_A\gamma_B - 2\gamma_A\mu_B + \mu_A\mu_B\gamma_C)}{\gamma_A\mu_B + \mu_A\gamma_B + \mu_A\mu_B\gamma_C} \leq 0$, if
$\mu_A \geq \widehat{\mu_{A_{2minBC}}} = \frac{2\gamma_A\mu_B}{\gamma_B + \mu_B\gamma_C}$.
$\widehat{\mu_{A_{2minBC}}} - \widehat{\mu_{A_{2minB}}} = \frac{2\gamma_A\mu_B}{\gamma_B + \mu_B\gamma_C} - \frac{\gamma_A\mu_B}{\gamma_B} = \frac{\gamma_A\mu_B(\gamma_B - \mu_B\gamma_C)}{\gamma_B(\gamma_B + \mu_B\gamma_C)} > 0$ if $\mu_B < \widehat{\mu_{B_{p_B=p_C}}} = \frac{\gamma_B}{\gamma_C}$
$\widehat{\mu_{A_{2minBC}}} - \widehat{\mu_{A_{2minC}}} = \frac{2\gamma_A\mu_B}{\gamma_B + \mu_B\gamma_C} - \frac{\gamma_A}{\gamma_C} = \frac{\gamma_A(\mu_B\gamma_C - \gamma_B)}{\gamma_C(\gamma_B + \mu_B\gamma_C)} > 0$ if $\mu_B > \widehat{\mu_{B_{p_B=p_C}}}$
Consistent scheme $2minB$: $p_B^{2minB} - p_C^{2minB} = -\frac{(\gamma_A\mu_B + \gamma_B\mu_A - 2\gamma_C\mu_A\mu_B)}{2\gamma_C(\gamma_A\mu_B + \gamma_B\mu_A)} \leq 0$, if
$\mu_A \leq \mu_A = \widehat{\mu_{A_{p_B^{2minB} = p_C^{2minB}}}} = \frac{\gamma_A\mu_B}{2\gamma_C\mu_B - \gamma_B}$, with

$\mu_{A_{\widehat{p_B^{2minB}=p_C^{2minB}}}} - \mu_{\widehat{A_{2minB}}} = 2\frac{\gamma_A}{\gamma_B}\mu_B\frac{\gamma_B-\gamma_C\mu_B}{2\gamma_C\mu_B-\gamma_B} \geq 0$ if $\mu_B < \mu_{\widehat{B_{p_B=p_C}}}$.
Consistent scheme $2minC$: $p_C^{2minC} - p_B^{2minC} = -\frac{(\gamma_A\mu_B-2\gamma_B\mu_A+\gamma_C\mu_A\mu_B)}{2\gamma_B(\gamma_A+\gamma_C\mu_A)} \leq 0$, if
$\mu_A \leq \mu_A = \mu_{A_{\widehat{p_B^{2minC}=p_C^{2minC}}}} = \frac{\gamma_A\mu_B}{2\gamma_B-\gamma_C\mu_B}$,
with $\mu_{A_{\widehat{p_B^{2minC}=p_C^{2minC}}}} - \mu_{\widehat{A_{2minC}}} = 2\frac{\gamma_A}{\gamma_C}\frac{\gamma_C\mu_B-\gamma_B}{2\gamma_B-\gamma_C\mu_B} \geq 0$ if $\mu_B > \mu_{\widehat{B_{p_B=p_C}}}$.

Equilibrium existence $2minB$: Consider the pricing strategy $\widetilde{p_A^{2minB}} = \widetilde{p_B^{2minB}} - \varepsilon$, which allows the manufacturer to avoid the price cap P_A^{2minB}. The manufacturer's profit is maximized for $\widetilde{p_B^{2minB}} = \frac{\mu_A\mu_B+\varepsilon\gamma_A\mu_B}{\gamma_A\mu_B+\mu_A\gamma_B}$, $\widetilde{p_A^{2minB}} = \widetilde{p_B^{2minB}} - \varepsilon = \frac{\mu_A(\mu_B-\varepsilon\gamma_B)}{\gamma_A\mu_B+\mu_A\gamma_B}$. The profit for this pricing strategy is $\pi\left(\widetilde{p_A^{2minB}}, \widetilde{p_B^{2minB}}, p_C\right) = \frac{\gamma_B\mu_A(\mu_A+\varepsilon\gamma_A)(\mu_B-\varepsilon\gamma_B)}{(\gamma_A\mu_B+\mu_A\gamma_B)^2}$
$+\frac{\gamma_A(\mu_A\mu_B+\varepsilon\gamma_A\mu_B)(\mu_B-\varepsilon\gamma_B)}{(\gamma_A\mu_B+\mu_A\gamma_B)^2} + \frac{1}{4\gamma_C}$, with
$\pi^{2minB}\left(p_A^{2minB}, p_B^{2minB}, p_C^{2minB}\right) - \pi\left(\widetilde{p_A^{2minB}}, \widetilde{p_B^{2minB}}, \widetilde{p_C^{2minB}}\right)$
$= \frac{\varepsilon(\mu_A\gamma_B-\gamma_A\mu_B+\varepsilon\gamma_A\gamma_B)}{\gamma_A\mu_B+\mu_A\gamma_B} > 0$, if $\mu_A > \mu_{\widehat{A_{\widetilde{2minB}}}} = \frac{(\gamma_A\mu_B-\varepsilon\gamma_A\gamma_B)}{\gamma_B}$. Note that
$\mu_{\widehat{A_{\widetilde{2minB}}}} < \mu_{\widehat{A_{2minB}}}$.

Equilibrium existence $2minC$: Consider the pricing strategy $\widetilde{p_A^{2minC}} = \widetilde{p_C^{2minC}} - \varepsilon$, which allows the manufacturer to avoid the price cap P_A^{2minC}. The manufacturer's profit is maximized for $\widetilde{p_C^{2minC}} = \frac{(\mu_A+\varepsilon\gamma_A)}{\gamma_A+\mu_A\gamma_C}$, $\widetilde{p_A^{2minC}} = \widetilde{p_B^{2minC}} - \varepsilon = \frac{\mu_A(1-\varepsilon\gamma_C)}{\gamma_A+\mu_A\gamma_C}$. The profit for this pricing strategy is $\pi\left(\widetilde{p_A^{2minC}}, p_B, \widetilde{p_C^{2minC}}\right) = \frac{\gamma_C\mu_A(\mu_A+\varepsilon\gamma_A)(1-\varepsilon\gamma_C)}{(\gamma_A+\gamma_C\mu_A)^2} + \frac{\gamma_A(\mu_A+\varepsilon\gamma_A)(1-\varepsilon\gamma_C)}{(\gamma_A+\gamma_C\mu_A)^2} + \frac{\mu_B}{4\gamma_B}$, with $\pi^{2minC}\left(p_A^{2minC}, p_B^{2minC}, p_C^{2minC}\right) - \pi\left(\widetilde{p_A^{2minC}}, \widetilde{p_B^{2minC}}, \widetilde{p_C^{2minC}}\right)$
$= \frac{\varepsilon(\mu_A\gamma_C-\gamma_A+\varepsilon\gamma_A\gamma_C)}{\gamma_A+\gamma_C\mu_A} > 0$, if $\mu_A > \mu_{\widehat{A_{\widetilde{2minC}}}} = \frac{(\gamma_A-\varepsilon\gamma_A\gamma_C)}{\gamma_C}$. Note that $\mu_{\widehat{A_{\widetilde{2minC}}}} < \mu_{\widehat{A_{2minC}}}$.

Equilibrium existence $2minBC$: Consider the pricing strategy $\widetilde{p_A^{2minBC}} = \widetilde{p_{BC}^{2minBC}} - \varepsilon$, which allows the manufacturer to avoid the price cap P_A^{2minBC}. The manufacturer's profit is maximized for $\widetilde{p_{BC}^{2minBC}} = \frac{3\mu_A\mu_B+2\varepsilon\gamma_A\mu_B}{2(\gamma_A\mu_B+\gamma_B\mu_A+\gamma_C\mu_A\mu_B)}$. The profit for this pricing strategy is $\pi\left(\widetilde{p_A^{2minBC}}, \widetilde{p_{BC}^{2minBC}}\right) =$
$\frac{\mu_A(3\mu_B-2\varepsilon\gamma_B-2\varepsilon\mu_B\gamma_C)(-\gamma_A\mu_B+2\mu_A\gamma_B+2\varepsilon\gamma_A\gamma_B+2\mu_A\mu_B\gamma_C+2\varepsilon\gamma_A\mu_B\gamma_C)}{4(\gamma_A\mu_B+\mu_A\gamma_B+\mu_A\mu_B\gamma_C)^2}$
$+\frac{\mu_B(2\gamma_A\mu_B-\mu_A\gamma_B-2\varepsilon\gamma_A\gamma_B+2\mu_A\mu_B\gamma_C)(3\mu_A+2\varepsilon\gamma_A)}{4(\gamma_A\mu_B+\mu_A\gamma_B+\mu_A\mu_B\gamma_C)^2}$
$+\frac{\mu_B(3\mu_A+2\varepsilon\gamma_A)(2\gamma_A\mu_B+2\mu_A\gamma_B-\mu_A\mu_B\gamma_C-2\varepsilon\gamma_A\mu_B\gamma_C)}{4(\gamma_A\mu_B+\mu_A\gamma_B+\mu_A\mu_B\gamma_C)^2}$, with
$\pi^{2minBC} - \pi\left(\widetilde{p_A^{2minBC}}, \widetilde{p_{BC}^{2minBC}}\right) =$
$\frac{\varepsilon(\mu_A\gamma_B-2\gamma_A\mu_B+\varepsilon\gamma_A\gamma_B+\mu_A\mu_B\gamma_C+\varepsilon\gamma_A\mu_B\gamma_C)}{\gamma_A\mu_B+\mu_A\gamma_B+\mu_A\mu_B\gamma_C} > 0$, if $\mu_A > \mu_{\widehat{A_{\widetilde{2minBC}}}} = \gamma_A\frac{2\mu_B-\varepsilon\gamma_B-\varepsilon\mu_B\gamma_C}{\gamma_B+\mu_B\gamma_C}$.
Note that $\mu_{\widehat{A_{\widetilde{2minBC}}}} < \mu_{\widehat{A_{2minBC}}}$.

External Reference Pricing Scheme 2avg

Binding price cap P_A^{2avg}: $p_A^{2avg} - p_A^* = \frac{\mu_A(2\gamma_B\gamma_C\mu_A - \gamma_A\gamma_C\mu_B - \gamma_A\gamma_B)}{\gamma_A(\gamma_A\gamma_B + \gamma_A\gamma_C\mu_B + 4\gamma_B\gamma_C\mu_A)} \leq 0$ if $\mu_A \geq \frac{(\gamma_A\gamma_B + \gamma_A\gamma_C\mu_B)}{2\gamma_B\gamma_C} \leq 0$ if $\mu_A \geq \widehat{\mu_{A_{2avg}}} = \frac{\gamma_A\gamma_B + \gamma_A\gamma_C\mu_B}{2\gamma_B\gamma_C}$.

Equilibrium existence $2avg$: Consider the pricing strategy $\widetilde{p_A^{2avg}} = \frac{1}{2}\widetilde{p_B^{2avg}} + \frac{1}{2}\widetilde{p_C^{2avg}} - \varepsilon$, which allows the manufacturer to avoid the price cap P_A^{2minBC}. The manufacturer's profit is maximized for $\widetilde{p_B^{2avg}} = \frac{\mu_B\gamma_C(3\mu_A + 2\varepsilon\gamma_A)}{\gamma_A\gamma_B + \gamma_A\mu_B\gamma_C + 4\mu_A\gamma_B\gamma_C}$, $\widetilde{p_C^{2avg}} = \frac{\gamma_B(3\mu_A + 2\varepsilon\gamma_A)}{\gamma_A\gamma_B + \gamma_A\mu_B\gamma_C + 4\mu_A\gamma_B\gamma_C}$. The profit for this pricing strategy is $\pi\left(\widetilde{p_B^{2avg}}, \widetilde{p_C^{2avg}}\right) =$

$\frac{\mu_A(-\gamma_A\gamma_B - \gamma_A\mu_B\gamma_C + 8\mu_A\gamma_B\gamma_C + 8\varepsilon\gamma_A\gamma_B\gamma_C)(3\gamma_B + 3\mu_B\gamma_C - 8\varepsilon\gamma_B\gamma_C)}{4(\gamma_A\gamma_B + \gamma_A\mu_B\gamma_C + 4\mu_A\gamma_B\gamma_C)^2}$

$+ \frac{(3\mu_A + 2\varepsilon\gamma_A)\gamma_C\mu_B(\gamma_A\gamma_B + \gamma_A\mu_B\gamma_C + \mu_A\gamma_B\gamma_C - 2\varepsilon\gamma_A\gamma_B\gamma_C)}{(\gamma_A\gamma_B + \gamma_A\mu_B\gamma_C + 4\mu_A\gamma_B\gamma_C)^2}$

$+ \frac{\gamma_B(3\mu_A + 2\varepsilon\gamma_A)(\gamma_A\gamma_B + \gamma_A\mu_B\gamma_C + \mu_A\gamma_B\gamma_C - 2\varepsilon\gamma_A\gamma_B\gamma_C)}{(\gamma_A\gamma_B + \gamma_A\mu_B\gamma_C + 4\mu_A\gamma_B\gamma_C)^2}$, with $\pi^{2avg} - \pi\left(\widetilde{p_B^{2avg}}, \widetilde{p_C^{2avg}}\right)$

$= 2\frac{\varepsilon(2\mu_A\gamma_B\gamma_C - \gamma_A\mu_B\gamma_C - \gamma_A\gamma_B + 2\varepsilon\gamma_A\gamma_B\gamma_C)}{\gamma_A\gamma_B + \gamma_A\mu_B\gamma_C + 4\mu_A\gamma_B\gamma_C} > 0$, if

$\mu_A > \widehat{\mu_{A_{\widetilde{2avg}}}} = \frac{(\gamma_A\gamma_B + \gamma_A\mu_B\gamma_C - 2\varepsilon\gamma_A\gamma_B\gamma_C)}{2\gamma_B\gamma_C}$. Note that $\widehat{\mu_{A_{\widetilde{avg}}}} < \widehat{\mu_{A_{2avg}}}$.

A.2 Choice of Regulatory Scheme

Minimum price rule vs. average price rule, $2minB$:

$p_A^{2avg} - p_A^{2minB} = -\frac{\mu_A\left(5\gamma_B\gamma_C\mu_A\mu_B - \gamma_A\mu_B^2\gamma_C - \gamma_A\gamma_B\mu_B - 3\gamma_B^2\mu_A\right)}{2(\gamma_A\mu_B + \mu_A\gamma_B)(\gamma_A\gamma_B + \gamma_A\gamma_C\mu_B + 4\gamma_B\gamma_C\mu_A)} \leq 0$

if $\mu_A \geq \mu_{A_{\widehat{p_A^{2avg} = p_A^{2minB}}}} = \frac{\gamma_A\mu_B(\gamma_B + \gamma_C\mu_B)}{\gamma_B(5\gamma_C\mu_B - 3\gamma_B)}$, $\mu_{A_{\widehat{p_A^{2avg} = p_A^{2minB}}}} \geq 0$ if $\mu_B > \underline{\mu_B} = \frac{3\gamma_B}{5\gamma_C}$,

$\mu_{A_{\widehat{p_A^{2avg} = p_A^{2minB}}}} - \mu_{A_{\widehat{p_B^{2minB} = p_C^{2minB}}}} = 2\frac{\gamma_A}{\gamma_B}\frac{\mu_B(\gamma_B - \mu_B\gamma_C)^2}{3\gamma_B^2 - 11\gamma_B\mu_B\gamma_C + 10\mu_B^2\gamma_C^2} > 0$

if $\mu_B < \underline{\underline{\mu_B}} = \frac{1}{2}\frac{\gamma_B}{\gamma_C} \vee \mu_B > \underline{\mu_B}$.

Minimum price rule vs. average price rule, $2minC$:

$p_A^{2avg} - p_A^{2minC} = -\frac{\mu_A\left(5\gamma_B\gamma_C\mu_A - 3\gamma_C^2\mu_A\mu_B - \gamma_A\gamma_C\mu_B - \gamma_A\gamma_B\right)}{2(\gamma_A + \gamma_C\mu_A)(\gamma_A\gamma_B + \gamma_A\gamma_C\mu_B + 4\gamma_B\gamma_C\mu_A)} \leq 0$

if $\mu_A \geq \mu_{A_{\widehat{p_A^{2avg} = p_A^{2minC}}}} = \frac{(\gamma_A\gamma_B + \gamma_A\gamma_C\mu_B)}{\gamma_C(5\gamma_B - 3\gamma_C\mu_B)}$, $\mu_{A_{\widehat{p_A^{2avg} = p_A^{2minC}}}} \geq 0$ if $\mu_B < \overline{\mu_B} = \frac{5\gamma_B}{3\gamma_C}$,

$\mu_{A_{\widehat{p_A^{2avg} = p_A^{2minC}}}} - \mu_{A_{\widehat{p_B^{2minC} = p_C^{2minC}}}} = 2\frac{\gamma_A}{\gamma_C}\frac{(\gamma_B - \mu_B\gamma_C)^2}{10\gamma_B^2 - 11\gamma_B\mu_B\gamma_C + 3\mu_B^2\gamma_C^2} > 0$

if $\mu_B < \overline{\mu_B} \vee \mu_B > \overline{\overline{\mu_B}} = 2\frac{\gamma_B}{\gamma_C}$.

Minimum price rule vs. average price rule, $2minBC$:

$p^{2minBC} - p_A^{2avg} = \frac{3\mu_A^2(\gamma_B - \gamma_C\mu_B)^2}{2(\gamma_A\mu_B + \gamma_B\mu_A + \gamma_C\mu_A\mu_B)(\gamma_A\gamma_B + \gamma_A\gamma_C\mu_B + 4\gamma_B\gamma_C\mu_A)} > 0.$

A.3 Welfare in Reference Countries

$p_B^{2minB} - p_B^* = \frac{\mu_B(\gamma_B\mu_A - \gamma_A\mu_B)}{2\gamma_B(\gamma_A\mu_B + \mu_A\gamma_B)} > 0$

$p_C^{2minC} - p_C^* = \frac{\gamma_C\mu_A - \gamma_A}{2\gamma_C(\gamma_A + \mu_A\gamma_C)} > 0$

$p_B^{avg} - p_B^* = \frac{\mu_B(2\gamma_B\gamma_C\mu_A - \gamma_A\gamma_C\mu_B - \gamma_A\gamma_B)}{2\gamma_B(\gamma_A\gamma_B + \gamma_A\gamma_C\mu_B + 4\gamma_B\gamma_C\mu_A)} > 0$
$p_C^{avg} - p_C^* = \frac{(2\gamma_B\gamma_C\mu_A - \gamma_A\gamma_B - \gamma_A\gamma_C\mu_B)}{2\gamma_C(\gamma_A\gamma_B + \gamma_A\gamma_C\mu_B + 4\gamma_B\gamma_C\mu_A)} > 0$
$p_B^{2minBC} - p_B^* = \frac{\mu_B(2\mu_A\gamma_B - \gamma_A\mu_B - \mu_A\mu_B\gamma_C)}{2\gamma_B(\gamma_A\mu_B + \mu_A\gamma_B + \mu_A\mu_B\gamma_C)} > 0$ if $\mu_A \geq \widehat{\mu_{A_{p_B^{2minC} = p_C^{2minC}}}} = \frac{\gamma_A\mu_B}{2\gamma_B - \gamma_C\mu_B}$
$p_C^{2minBC} - p_C^* = \frac{2\mu_A\mu_B\gamma_C - \mu_A\gamma_B - \gamma_A\mu_B}{2\gamma_C(\gamma_A\mu_B + \mu_A\gamma_B + \mu_A\mu_B\gamma_C)} > 0$ if $\mu_A \geq \widehat{\mu_{A_{p_B^{2minB} = p_C^{2minB}}}} = \frac{\gamma_A\mu_B}{2\gamma_C\mu_B - \gamma_B}$
$\Delta W_A = \frac{\mu_A\left(\mu_A^2\left(\gamma_B^2 + \mu_B^2\gamma_C^2\right) - 8\gamma_A^2\mu_B^2 + 2\mu_A\mu_B(\gamma_A\gamma_B + \gamma_A\mu_B\gamma_C + \mu_A\gamma_B\gamma_C)\right)}{8(\gamma_A\mu_B + \mu_A\gamma_B + \mu_A\mu_B\gamma_C)^2} > 0$ if $\mu_A > \widehat{\mu_{A_{2minBC}}}$
$\Delta W_B = \frac{\mu_B\left(\mu_B^2\left(\gamma_A^2 + \mu_A^2\gamma_C^2\right) - 8\mu_A^2\gamma_B^2 + 2\mu_A\mu_B(\gamma_A\gamma_B + \gamma_A\mu_B\gamma_C + \mu_A\gamma_B\gamma_C)\right)}{8(\gamma_A\mu_B + \mu_A\gamma_B + \mu_A\underline{\mu_B\gamma_C})^2} > 0$ if
$\mu_B < \overline{\overline{\mu_B}} \wedge \mu_A < \widehat{\mu_{A_{p_B^{2minC} = p_C^{2minC}}}} \vee \mu_B > \overline{\overline{\mu_B}}$
$\Delta W_C = \frac{\gamma_A^2\mu_B^2 + \mu_A^2\gamma_B^2 - 8\mu_A^2\mu_B^2\gamma_C^2 + 2\mu_A\mu_B(\gamma_A\gamma_B + \gamma_A\mu_B\gamma_C + \mu_A\gamma_B\gamma_C)}{8(\gamma_A\mu_B + \mu_A\gamma_B + \mu_A\mu_B\gamma_C)^2} > 0$
if $\mu_B > \underline{\underline{\mu_B}} \wedge \mu_A < \widehat{\mu_{A_{p_B^{2minB} = p_C^{2minB}}}} \vee \mu_B < \underline{\underline{\mu_B}}$.
Global welfare under coinsurance: $W^* = \frac{3}{8}\mu_A + \frac{3}{8}\mu_B + \frac{3}{8}$
Global welfare under uniform price: $W^p = \frac{\mu_A(5\gamma_A\mu_B + 2\mu_A\gamma_B + 2\mu_A\mu_B\gamma_C)(2\mu_A\mu_B\gamma_C - \gamma_A\mu_B + 2\mu_A\gamma_B)}{8(\gamma_A\mu_B + \mu_A\gamma_B + \mu_A\mu_B\gamma_C)^2} +$
$\frac{\mu_B(2\gamma_A\mu_B - \mu_A\gamma_B + 2\mu_A\mu_B\gamma_C)(2\gamma_A\mu_B + 5\mu_A\gamma_B + 2\mu_A\mu_B\gamma_C)}{8(\gamma_A\mu_B + \mu_A\gamma_B + \mu_A\mu_B\gamma_C)^2} + \frac{(2\gamma_A\mu_B + 2\mu_A\gamma_B + 5\mu_A\mu_B\gamma_C)(2\gamma_A\mu_B + 2\mu_A\gamma_B - \mu_A\mu_B\gamma_C)}{8(\gamma_A\mu_B + \mu_A\gamma_B + \mu_A\mu_B\gamma_C)^2}$
$W^p - W^* = \frac{\Omega_W}{8(\gamma_A\mu_B + \mu_A\gamma_B + \mu_A\mu_B\gamma_C)^2} > 0$, with $\Omega_W = \gamma_A^2\mu_B^2(\mu_B + 1) + \mu_A^2\gamma_B^2(\mu_A + 1) +$
$\mu_A^2\mu_B^2\gamma_C^2(\mu_A + \mu_B) - 8\mu_A\mu_B\left(\mu_A\gamma_B^2 + \gamma_A^2\mu_B + \mu_A\mu_B\gamma_C^2\right)$
$+2\mu_A\mu_B(\mu_A + \mu_B + 1)(\gamma_A\gamma_B + \gamma_A\mu_B\gamma_C + \mu_A\gamma_B\gamma_C)$

A.4 Mutual Referencing

One reference country: $p - p_C^{1B} = -\frac{(\gamma_A\mu_B + \gamma_B\mu_A - 2\mu_A\gamma_C\mu_B)}{2\gamma_C(\gamma_A\mu_B + \gamma_B\mu_A + \gamma_C\mu_A\mu_B)} < 0$ if $\mu_A \leq \widehat{\mu_{A_{p_B^{2minB} = p_C^{2minB}}}}$.
$p - p_C^{1B} = -\frac{1}{2\gamma_B}\frac{\mu_B(\gamma_A\mu_B - 2\gamma_B\mu_A + \gamma_C\mu_A\mu_B)}{\gamma_A\mu_B + \gamma_B\mu_A + \gamma_C\mu_A\mu_B} < 0$, if $\mu_A \leq \widehat{\mu_{A_{p_B^{2minC} = p_C^{2minC}}}}$.
Two reference countries, minimum price:
$p - p_C^{2minB} = -\frac{(\gamma_A\mu_B + \gamma_B\mu_A - 2\gamma_C\mu_A\mu_B)}{2\gamma_C(\gamma_A\mu_B + \gamma_B\mu_A + \gamma_C\mu_A\mu_B)} < 0$ if $\mu_A \leq \widehat{\mu_{A_{p_B^{2minB} = p_C^{2minB}}}}$
Two reference countries, average price:
$p - p_B^{2avg} = -\frac{3\mu_A\mu_B(\gamma_A + 2\gamma_C\mu_A)(\gamma_C\mu_B - \gamma_B)}{2(\gamma_A\mu_B + \gamma_B\mu_A + \gamma_C\mu_A\mu_B)(\gamma_A\gamma_B + \gamma_A\gamma_C\mu_B + 4\gamma_B\gamma_C\mu_A)} < 0$ if $\mu_B > \widehat{\mu_{B_{p_B = p_C}}}$,
$p - p_B^{2avg} = -\frac{3}{2}\frac{(\gamma_A\mu_B + 2\gamma_B\mu_A)\mu_A(\gamma_B - \gamma_C\mu_B)}{(\gamma_A\mu_B + \gamma_B\mu_A + \gamma_C\mu_A\mu_B)(\gamma_A\gamma_B + \gamma_A\gamma_C\mu_B + 4\gamma_B\gamma_C\mu_A)} < 0$ if $\mu_B < \widehat{\mu_{B_{p_B = p_C}}}$.
$p - p_A^{2minB} = \frac{\mu_A\mu_B(\gamma_A\mu_B + \gamma_B\mu_A - 2\gamma_C\mu_A\mu_B)}{2(\gamma_A\mu_B + \gamma_B\mu_A)(\gamma_A\mu_B + \gamma_B\mu_A + \gamma_C\mu_A\mu_B)} > 0$ if $\mu_A < \widehat{\mu_{A_{p_B^{2minC} = p_C^{2minC}}}}$
$p - p_A^{2minC} = \frac{\mu_A(\gamma_A\mu_B - 2\gamma_B\mu_A + \gamma_C\mu_A\mu_B)}{2(\gamma_A + \gamma_C\mu_A)(\gamma_A\mu_B + \gamma_B\mu_A + \gamma_C\mu_A\mu_B)} > 0$, if $\mu_A < \widehat{\mu_{A_{p_B^{2minB} = p_C^{2minB}}}}$
$p - p_A^{2avg} = \frac{3\mu_A^2(\gamma_B - \gamma_C\mu_B)^2}{2(\gamma_A\mu_B + \gamma_B\mu_A + \gamma_C\mu_A\mu_B)(\gamma_A\gamma_B + \gamma_A\gamma_C\mu_B + 4\gamma_B\gamma_C\mu_A)} > 0$

A.5 Endogenous Export Decision

One Reference Country

$1B$ vs. no exports to B and coinsurance in A and C:
$\pi_A^* + \pi_C^* - \pi^{1B} = \frac{\mu_A(\gamma_B\mu_A - 3\gamma_A\mu_B)}{4\gamma_A(\gamma_A\mu_B + \gamma_B\mu_A)} > 0$, if $\mu_A > \widetilde{\mu_{A_{1B,A^*C^*}}} = \frac{3\gamma_A\mu_B}{\gamma_B}$.
$1B$ vs. no exports to B and $1C$:
$\pi_A^{1C} + \pi_C^{1C} - \pi^{1B} = \frac{\mu_A^2\gamma_C(3\gamma_B - 4\gamma_C\mu_B) - \gamma_A(\gamma_A\mu_B + \gamma_B\mu_A + \gamma_C\mu_A\mu_B)}{4\gamma_C(\gamma_A + \gamma_C\mu_A)(\gamma_A\mu_B + \gamma_B\mu_A)} > 0$
if $\mu_A > \widetilde{\mu_{A_{1B,1C}}} = \frac{\gamma_A\left(\gamma_B + \gamma_C\mu_B + \sqrt{(\gamma_B - \gamma_C\mu_B)(\gamma_B + 15\gamma_C\mu_B)}\right)}{2\gamma_C(3\gamma_B - 4\gamma_C\mu_B)} \wedge \mu_B < \widetilde{\mu_{B_{1B,1C}}} = \frac{3\gamma_B}{4\gamma_C}$.
$1B$ vs. no exports to B and C:
$\pi_A^* - \pi^{1B} = \frac{\mu_A^2\gamma_B\gamma_C - \gamma_A^2\mu_B - \gamma_A\mu_A(\gamma_B + 3\gamma_C\mu_B)}{4\gamma_A\gamma_C(\gamma_A\mu_B + \gamma_B\mu_A)} > 0$
if $\mu_A > \widetilde{\mu_{A_{1B,A^*}}} = \frac{\gamma_A\left(\gamma_B + 3\gamma_C\mu_B + \sqrt{(\gamma_B + \gamma_C\mu_B)(\gamma_B + 9\gamma_C\mu_B)}\right)}{2\gamma_B\gamma_C}$.
$1C$ vs. no exports to C and coinsurance in A and B:
$\pi_A^* + \pi_B^* - \pi^{1C} = \frac{\mu_A(\gamma_C\mu_A - 3\gamma_A)}{4\gamma_A(\gamma_A + \gamma_C\mu_A)} > 0$ if $\mu_A > \widetilde{\mu_{A_{1C,A^*B^*}}} = \frac{3\gamma_A}{\gamma_C}$.
$1C$ vs. no exports to C and $1B$:
$\pi_A^{1B} + \pi_B^{1B} - \pi^{1C} = \frac{\mu_A^2\gamma_B(3\gamma_C\mu_B - 4\gamma_B) - \gamma_A\mu_B(\gamma_A\mu_B + \gamma_B\mu_A + \gamma_C\mu_A\mu_B)}{4\gamma_B(\gamma_A + \gamma_C\mu_A)(\gamma_A\mu_B + \gamma_B\mu_A)} > 0$
if $\mu_A > \widetilde{\mu_{A_{1C,1B}}} = \frac{\gamma_A\mu_B\left(\gamma_B + \gamma_C\mu_B + \sqrt{(\gamma_C\mu_B - \gamma_B)(15\gamma_B + \gamma_C\mu_B)}\right)}{2\gamma_B(3\gamma_C\mu_B - 4\gamma_B)} \wedge \mu_B > \widetilde{\mu_{B_{1C,1B}}} = \frac{4\gamma_B}{3\gamma_C}$
$1C$ vs. no exports to B and C:
$\pi_A^* - \pi^{1C} = \frac{\mu_A^2\gamma_B\gamma_C - \gamma_A^2\mu_B - \gamma_A\mu_A(3\gamma_B + \mu_B\gamma_C)}{4\gamma_A\gamma_B(\gamma_A + \gamma_C\mu_A)} > 0$
if $\mu_A > \widetilde{\mu_{A_{1C,A^*}}} = \frac{\gamma_A\left(3\gamma_B + \mu_B\gamma_C + \sqrt{(\gamma_B + \gamma_C\mu_B)(9\gamma_B + \gamma_C\mu_B)}\right)}{2\gamma_B\gamma_C}$.

Two Reference Countries, Minimum Rule

$2minB$ vs. no exports to B and $1C$:
$\pi_A^{1C} + \pi_C^{1C} - \pi^{2minB} = \frac{\mu_A^2\gamma_C(3\gamma_B - 4\gamma_C\mu_B) - \gamma_A(\gamma_A\mu_B + \gamma_B\mu_A + \gamma_C\mu_A\mu_B)}{4\gamma_C(\gamma_A + \gamma_C\mu_A)(\gamma_A\mu_B + \gamma_B\mu_A)} > 0$
if $\mu_A > \widetilde{\mu_{A_{2minB,1C}}} = \frac{\gamma_A\left(\gamma_B + \gamma_C\mu_B + \sqrt{(\gamma_B - \gamma_C\mu_B)(\gamma_B + 15\gamma_C\mu_B)}\right)}{2\gamma_C(3\gamma_B - 4\gamma_C\mu_B)} \wedge \mu_B < \widetilde{\mu_{B_{2minB,1C}}} = \frac{3\gamma_B}{4\gamma_C}$.
$2minB$ vs. no exports to B and C:
$\pi_A^* - \pi^{2minB} = \frac{\mu_A^2\gamma_B\gamma_C - \gamma_A^2\mu_B - \gamma_A\mu_A(\gamma_B + 3\gamma_C\mu_B)}{4\gamma_A\gamma_C(\gamma_A\mu_B + \gamma_B\mu_A)} > 0$
if $\mu_A > \widetilde{\mu_{A_{2minB,A^*}}} \frac{\gamma_A\left(\gamma_B + 3\gamma_C\mu_B + \sqrt{(\gamma_B + \gamma_C\mu_B)(\gamma_B + 9\gamma_C\mu_B)}\right)}{2\gamma_B\gamma_C}$.
$2minC$ vs. no exports to C and $1B$:
$\pi_A^{1B} + \pi_B^{1B} - \pi^{2minC} = \frac{\mu_A^2\gamma_B(3\mu_B\gamma_C - 4\gamma_B) - \gamma_A\mu_B(\gamma_A\mu_B + \mu_A\gamma_B + \mu_A\mu_B\gamma_C)}{4\gamma_B(\gamma_A + \mu_A\gamma_C)(\gamma_A\mu_B + \mu_A\gamma_B)} > 0$
if $\mu_A > \widetilde{\mu_{A_{2minC,1B}}} = \frac{\gamma_A\mu_B\left(\gamma_B + \mu_B\gamma_C + \sqrt{(\mu_B\gamma_C - \gamma_B)(15\gamma_B + \mu_B\gamma_C)}\right)}{2\gamma_B(3\mu_B\gamma_C - 4\gamma_B)} \wedge \mu_B > \widetilde{\mu_{B_{2minC,1B}}} = \frac{4\gamma_B}{3\gamma_C}$.
$2minC$ vs. no exports to B and C:
$\pi_A^* - \pi^{2minC} = \frac{\mu_A^2\gamma_B\gamma_C - \gamma_A^2\mu_B - \gamma_A\mu_A(3\gamma_B + \mu_B\gamma_C)}{4\gamma_A\gamma_B(\gamma_A + \mu_A\gamma_C)} > 0$

if $\mu_A > \widetilde{\mu_{A_{2minC,A^*}}} = \frac{\gamma_A\left(3\gamma_B+\mu_B\gamma_C+\sqrt{(\gamma_B+\mu_B\gamma_C)(9\gamma_B+\mu_B\gamma_C)}\right)}{2\gamma_B\gamma_C}$

$2minBC$ vs. no exports to B and $1C$:

$\pi_A^{1C}+\pi_C^{1C}-\pi^{2minBC} = \frac{\mu_A(4\gamma_B\mu_A-5\gamma_A\mu_B-5\gamma_C\mu_A\mu_B)}{4(\gamma_A+\gamma_C\mu_A)(\gamma_A\mu_B+\gamma_B\mu_A+\gamma_C\mu_A\mu_B)} > 0$

if $\mu_A > \widetilde{\mu_{A_{2minBC,1C}}} = \frac{5\gamma_A\mu_B}{4\gamma_B-5\mu_B\gamma_C} \wedge \mu_B < \widetilde{\mu_{B_{2minBC,1C}}} = \frac{4\gamma_B}{5\gamma_C}$.

$2minBC$ vs. no exports to C and $1B$:

$\pi_A^{1B}+\pi_B^{1B}-\pi^{2minBC} = \frac{\mu_A\mu_B(4\gamma_C\mu_A\mu_B-5\gamma_B\mu_A-5\gamma_A\mu_B)}{4(\gamma_A\mu_B+\gamma_B\mu_A)(\gamma_A\mu_B+\gamma_B\mu_A+\gamma_C\mu_A\mu_B)} > 0$

if $\mu_A > \widetilde{\mu_{A_{2minBC,1B}}} = \frac{5\gamma_A\mu_B}{4\mu_B\gamma_C-5\gamma_B} \wedge \mu_B > \widetilde{\mu_{B_{2minBC,1B}}} = \frac{5\gamma_B}{4\gamma_C}$

$2minBC$ vs. no exports to B and C:

$\pi_A^*-\pi^{2minBC} = \frac{\mu_A(\gamma_B\mu_A-8\gamma_A\mu_B+\gamma_C\mu_A\mu_B)}{4\gamma_A(\gamma_A\mu_B+\mu_A\gamma_B+\gamma_C\mu_A\mu_B)} > 0$ if $\mu_A > \widetilde{\mu_{A_{2minBC,A^*}}} = \frac{8\gamma_A\mu_B}{\gamma_B+\mu_B\gamma_C}$

Two Reference Countries, Average Rule

Avg vs. no exports to B and coinsurance in A and C:

$\pi_A^*+\pi_C^*-\pi^{2avg} = \frac{\gamma_A^2\gamma_B+\gamma_A^2\gamma_C\mu_B-4\gamma_C\mu_A(\gamma_A\gamma_B+2\gamma_A\gamma_C\mu_B-\gamma_B\gamma_C\mu_A)}{4\gamma_A\gamma_C(\gamma_A\gamma_B+\gamma_A\gamma_C\mu_B+4\gamma_B\gamma_C\mu_A)} > 0,$

if $\mu_A > \widetilde{\mu_{A_{avg,A^*C^*}}} = \frac{\gamma_A\left(\sqrt{\mu_B\gamma_C^3(3\gamma_B+4\mu_B\gamma_C)}+\gamma_B\gamma_C+2\mu_B\gamma_C^2\right)}{2\gamma_B\gamma_C^2}$.

Avg vs. no exports to C and coinsurance in A and B:

$\pi_A^*+\pi_B^*-\pi^{2avg} = \frac{\gamma_A^2\gamma_B\mu_B+\gamma_A^2\gamma_C\mu_B^2-4\gamma_B\mu_A(2\gamma_A\gamma_B+\gamma_A\gamma_C\mu_B-\gamma_B\gamma_C\mu_A)}{4\gamma_A\gamma_B(\gamma_A\gamma_B+\gamma_A\gamma_C\mu_B+4\gamma_B\gamma_C\mu_A)} > 0,$

if $\mu_A > \widetilde{\mu_{A_{avg,A^*B^*}}} = \frac{\gamma_A\left(\sqrt{\gamma_B^3(4\gamma_B+3\mu_B\gamma_C)}+2\gamma_B^2+\gamma_B\gamma_C\mu_B\right)}{2\gamma_B^2\gamma_C}$.

Avg vs. no exports to B and $1C$:

$\pi_A^{1C}+\pi_C^{1C}-\pi^{2avg} = \frac{\mu_A^2\gamma_C(7\gamma_B-9\gamma_C\mu_B)-5\gamma_A\mu_A(\gamma_C\mu_B+\gamma_B)}{4(\gamma_A+\gamma_C\mu_A)(\gamma_A\gamma_B+\gamma_A\gamma_C\mu_B+4\gamma_B\gamma_C\mu_A)} > 0$

if $\mu_A > \widetilde{\mu_{A_{avg,1C}}} = \frac{5\gamma_A(\gamma_B+\gamma_C\mu_B)}{\gamma_C(7\gamma_B-9\mu_B\gamma_C)} \wedge \mu_B < \widetilde{\mu_{B_{avg,1C}}} = \frac{7\gamma_B}{9\gamma_C}$.

Avg vs. no exports to C and $1B$:

$\pi_A^{1B}+\pi_B^{1B}-\pi^{2avg} = \frac{\mu_A^2\gamma_B(7\gamma_C\mu_B-9\gamma_B)-5\gamma_A\mu_A\mu_B(\gamma_B+\gamma_C\mu_B)}{4(\gamma_A\mu_B+\gamma_B\mu_A)(\gamma_A\gamma_B+\gamma_A\gamma_C\mu_B+4\gamma_B\gamma_C\mu_A)} > 0$

if $\mu_A > \widetilde{\mu_{A_{avg,1B}}} = \frac{5\gamma_A\left(\gamma_C\mu_B^2+\gamma_B\mu_B\right)}{\gamma_B(7\gamma_C\mu_B-9\gamma_B)} \wedge \mu_B > \widetilde{\mu_{B_{avg,1B}}} = \frac{9\gamma_B}{7\gamma_C}$.

Avg vs. no exports to B and C:

$\pi_A^*-\pi^{2avg} = \frac{\mu_A(\gamma_B\gamma_C\mu_A-2\gamma_A\gamma_C\mu_B-2\gamma_A\gamma_B)}{\gamma_A(\gamma_A\gamma_B+\gamma_A\mu_B\gamma_C+4\gamma_B\gamma_C\mu_A)} > 0$ if $\mu_A > \widetilde{\mu_{A_{avg,A^*}}} = \frac{2\gamma_A(\gamma_B+\gamma_C\mu_B)}{\gamma_B\gamma_C}$.

$\widetilde{\mu_{A_{avg,1C}}} - \widetilde{\mu_{A_{2minB,1C}}}$

$= \frac{\gamma_A\left((23\gamma_B-31\mu_B\gamma_C)(\gamma_B+\mu_B\gamma_C)-(7\gamma_B-9\mu_B\gamma_C)\sqrt{(\gamma_B-\mu_B\gamma_C)(\gamma_B+15\mu_B\gamma_C)}\right)}{2\gamma_C(3\gamma_B-4\mu_B\gamma_C)(7\gamma_B-9\mu_B\gamma_C)} > 0$

$\wedge \mu_B < \widetilde{\mu_{B_{2minB,1C}}} = \frac{3\gamma_B}{4\gamma_C}$

$\widetilde{\mu_{A_{avg,1B}}} - \widetilde{\mu_{A_{2minC,1B}}}$

$= \frac{\gamma_A\mu_B\left((31\gamma_B-23\mu_B\gamma_C)(\gamma_B+\mu_B\gamma_C)-(9\gamma_B-7\mu_B\gamma_C)\sqrt{(\mu_B\gamma_C-\gamma_B)(15\gamma_B+\mu_B\gamma_C)}\right)}{2\gamma_B(3\mu_B\gamma_C-4\gamma_B)(9\gamma_B-7\mu_B\gamma_C)} > 0$

$\wedge \mu_B > \widetilde{\mu_{B_{2minC,1B}}} = \frac{4\gamma_B}{3\gamma_C}$

$p_A^{2avg}-p_A^{1C} = -\frac{\mu_A\left(5\gamma_B\gamma_C\mu_A-3\gamma_C^2\mu_A\mu_B-\gamma_A\gamma_C\mu_B-\gamma_A\gamma_B\right)}{2(\gamma_A+\gamma_C\mu_A)(\gamma_A\gamma_B+\gamma_A\gamma_C\mu_B+4\gamma_B\gamma_C\mu_A)} \leq 0$

if $\mu_A \geq \mu_{A_{\widehat{p_A^{2avg}=p_A^{2minC}}}} = \frac{(\gamma_A\gamma_B+\gamma_A\gamma_C\mu_B)}{\gamma_C(5\gamma_B-3\gamma_C\mu_B)}$, $\mu_{A_{\widehat{p_A^{2avg}=p_A^{2minC}}}} \geq 0$ if $\mu_B < \overline{\mu_B} = \frac{5\gamma_B}{3\gamma_C}$

$p_A^{2avg} - p_A^{1B} = -\frac{\mu_A\left(5\gamma_B\gamma_C\mu_A\mu_B-\gamma_A\mu_B^2\gamma_C-\gamma_A\gamma_B\mu_B-3\gamma_B^2\mu_A\right)}{2(\gamma_A\mu_B+\mu_A\gamma_B)(\gamma_A\gamma_B+\gamma_A\gamma_C\mu_B+4\gamma_B\gamma_C\mu_A)} \leq 0$

if $\mu_A \geq \mu_{A_{\widehat{p_A^{2avg}=p_A^{2minB}}}} = \frac{\gamma_A\mu_B(\gamma_B+\gamma_C\mu_B)}{\gamma_B(5\gamma_C\mu_B-3\gamma_B)}$, $\mu_{A_{\widehat{p_A^{2avg}=p_A^{2minB}}}} \geq 0$ if $\mu_B > \underline{\mu_B} = \frac{3\gamma_B}{5\gamma_C}$

$\widetilde{\mu_{A_{avg,1C}}} - \mu_{A_{\widehat{p_A^{2avg}=p_A^{2minC}}}} = \frac{6\gamma_A(\gamma_B+\mu_B\gamma_C)(3\gamma_B-\mu_B\gamma_C)}{\gamma_C(7\gamma_B-9\mu_B\gamma_C)(5\gamma_B-3\mu_B\gamma_C)} > 0$ if $\mu_B < \frac{3\gamma_B}{\gamma_C}$

$\widetilde{\mu_{A_{avg,1B}}} - \mu_{A_{\widehat{p_A^{2avg}=p_A^{2minB}}}} = \frac{6\gamma_A\mu_B(3\mu_B\gamma_C-\gamma_B)(\gamma_B+\mu_B\gamma_C)}{\gamma_B(5\gamma_C\mu_B-3\gamma_B)(7\gamma_C\mu_B-9\gamma_B)} > 0$ if $\mu_B < \frac{3\gamma_B}{5\gamma_C} \vee \mu_B > \frac{\gamma_B}{3\gamma_C}$