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REFERENCE PRICING
Making Parallel Trade in Pharmaceuticals Work

Miyase Yesim Köksal

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Making Parallel Trade in Pharmaceuticals Work

Miyase Yesim Köksal [*]

Abstract

This paper shows that parallel trade makes pharmaceutical manufacturers reduce their prices in the home (importing) country more when it is combined with the healthcare reimbursement policy of reference pricing, requiring consumers to pay the full extra cost if they don't buy cheaper parallel imported drugs. On the other hand, contrary to intuition, reference pricing leaves price unchanged in the foreign (exporting) country. By and large, a change from coinsurance to reference pricing results in a pure transfer of wealth from the pharmaceutical manufacturers to the insurance providers without affecting consumers' pharmaceutical consumption or their out-of-pocket costs.

Introduction

"There are no miracles from miracle drugs that people cannot afford."
  - U.S. Senator Byron Dorgan, Democrat of North Dakota

Pfizer's top selling cholesterol-lowering medication, Lipitor, is sold for $320 in the U.S., but for only $164 in Canada; U.S. consumers thus pay almost twice the price for the same drug.[1] High pharmaceutical prices also increase costs for the U.S. health insurers, making them charge consumers higher premiums. At the same time, many U.S. consumers do not fill their prescriptions, reportedly because they could not afford to do so.[2] Cutting back on prescribed medicines can cause treatable conditions to escalate into severe medical problems with greater suffering, and the public cost of healthcare may then increase as well.

U.S. consumers and health insurers will probably continue to pay more for Lipitor until the patent expires in 2011 and generics enter the market. But a much-debated alternative would be to open the border for parallel trade, allowing intermediaries to buy Lipitor in Canada for resale in the U.S. [3] Such arbitrage, which has been legally practiced in the EU for three decades as a part of the general rules on free movement of goods, is the primary instrument for creating competition for any medicine during the life of its patent.[4]

An important concern, however, is that prices might not be lowered much in the home (high-price, importing) country, since many consumers might be price insensitive because their costs are largely covered by public or private insurance.[5] If consumers continue to buy the more expensive locally sourced drugs -those placed on the market directly from the

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[1] A study by the U.S. Congressional Budget Office confirms this pattern: Drug prices are 35% to 55% higher in the U.S. than in Canada (Dorgan, 2007).

[2] An April 2008 study by the Kaiser Family Foundation found that 45% of uninsured and 22% of insured non-elderly adults (aged 18-64) had not filled a prescription because of cost; also see Saul (2008).

[3] U.S. lawmakers have recently proposed several bills to allow parallel trade: the Medicine Equity and Drug Safety Act of 2000; the Pharmaceutical Market Access Act of 2003; and the Pharmaceutical Market Access and Drug Safety Act of 2007 and 2009. The first two passed and allow parallel trade conditional on the Secretary of Health and Human Services' safety approval, which, however, has not been given to date. For the recent legislative history see www.cptech.org/ip/fsd/health-pi-us.html .

[4] The so called me-too drugs, with chemically related active substances that are pharmacologically equivalent, create competition as well, but not as much as do parallel imported drugs with the same active substances, which are virtually identical substitutes.

[5] Another important concern is the effect of parallel trade on the profits from and thus incentives for R&D. Pharmaceutical companies claim that parallel trade erodes profits and thereby decreases investment in R&D. This issue has been much debated (Danzon, 1998; Pecorino, 2002; Schlaepfer, 2008; Grossman and Lai, 2008; Bardey et al., 2009), but I do not consider it further here.

manufacturer by licensed wholesalers- there is little reason for manufacturers to reduce prices. Most of the gain then accrues to the parallel traders.

This paper shows that reference pricing – a healthcare reimbursement policy introduced mainly in some European countries as a demand-side cost-containment policy – could be a solution.[6] With reference pricing, drugs are clustered according to chemical, pharmacological, or therapeutic equivalence, and a reference price is defined for each cluster. If the price of the drug consumers buy is less than or equal to the reference price, consumers pay only a percentage of it. But if it is more, they pay a percentage of the reference price plus the difference between it and the drug price. Compared to the common provision of coinsurance – in which consumers pay a percentage of the price of the drug they choose, and the rest is borne by the insurer – reference pricing increases consumers' price sensitivity, rectifying the distortion created by insurance.

The impact of reference pricing on pharmaceutical companies' pricing strategies has been addressed both theoretically (Mestre-Ferrandiz, 2003; Brekke et al., 2007; Miraldo, 2009) and empirically (Aronsson, Bergman, and Rudholm, 2001; Pavcnik, 2002; Bergman and Rudholm, 2003; Brekke et al., 2008). However, this strand of research has mainly focused on generic competition, without considering competition exerted by parallel imports.

On the other hand, although there are quite a few studies on parallel trade, so far no one has investigated the implications of reference pricing in this context. Instead, previous theoretical research has examined the effects of parallel trade on pricing and welfare, accounting for cross-country demand dispersion (Malueg and Schwartz, 1994), vertical price control (Maskus and Chen, 2004; Chen and Maskus, 2005), pharmaceutical price regulations (Pecorino, 2002; Ganslandt and Maskus, 2004), supply limits (Ganslandt and Maskus, 2004), and cross-country differences in both coinsurance rates and valuation of pharmaceuticals (Jelovac and Bordoy, 2005).

This paper merges and extends the two strands of literature, on reference pricing and on parallel trade, by studying the implications of parallel trade for prices and welfare when

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[6] The EU countries currently using reference pricing are, in historical order, Germany, Netherlands, Denmark, Sweden, Spain, Belgium, Italy, Poland and Slovenia; also Canada (British Colombia), New Zealand, and Australia outside the EU.

combined with reference pricing. In order to fulfil this objective, reference pricing is introduced into Jelovac and Bordoy's (2005) two-country model of parallel trade so that insurance only covers a percentage of the cost of the cheapest alternative, the parallel imported drug, while consumers pay the full extra cost if they instead buy the locally sourced drug.[7]

It is assumed that a monopoly manufacturer holds the patent and supplies both countries with a certain drug. The two countries differ in their consumers' valuations of the drug, as well as in the share of the price (coinsurance rate) their consumers pay directly, and thus the manufacturer prices the drug differently in the two countries. Public insurance in each country is assumed to refund consumers' pharmaceutical consumption given the rule of reimbursement (coinsurance or reference pricing). In a perfectly competitive market with no costs of trade, parallel traders buy the drug in the low-price foreign country and resell it in the high-price home country.[8] Although there are no real differences, parallel imported drug is assumed to be perceived by consumers as an imperfect (inferior) substitute for the locally sourced one, since it is repackaged or relabelled.[9]

Given these assumptions, parallel trade causes greater price reductions in the home country under reference pricing than under coinsurance while, contrary to intuition, leaving price unchanged in the foreign country. By and large, a change from coinsurance to reference pricing results in a pure transfer of wealth from the pharmaceutical manufacturer to the public insurance without affecting consumers' pharmaceutical consumption or their out-of-pocket costs.

Benefits of Reference Pricing compared to Coinsurance in the Context of Parallel Trade

The model shows that parallel trade, when combined with reference pricing, increases competition, and hence reduces prices in the home country more than it does under

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[7] Although reference pricing policies differ significantly from country to country (Lopez-Casasnovas and Puig-Junoy, 2000, reviews reference pricing extensively), it is assumed here that drugs with the same active substance are clustered together, with the reference price set equal to that of the cheapest drug in the cluster, as is currently the case in Denmark and Sweden.

[8] The assumption of perfect competition is consistent with observed market structure, since for example, in a 2006 report by a biopharma market-research company, Spectra Intelligence, the UK is reported to have 70 parallel importers.

[9] Kanavos and Holmes (2005) report confusion and concerns about parallel imports among epilepsy patients.

coinsurance. What about the effect in the foreign country? One public concern is that manufacturers might reduce supply and increase prices in the foreign country in an attempt to deter parallel trade. Two of the big pharmaceutical manufacturers, GlaxoSmithKline and AstraZeneca, announced that they would cut shipments to Canada if their products were resold to Americans (Harris, 2003). As a result Canadians might not fill all their prescriptions. Even now Greeks cannot get some vital medicines because they are re-exported in such large quantities to other countries in Europe (Morgan, 2008). On the other hand, afraid of similar problems in Canada, the Canadian health minister announced that they would place restrictions on bulk export of drugs to the U.S. countering a move in the U.S. Congress to legalize the import of Canadian drugs (Struck, 2005).

Given this possible strategic response of pharmaceutical manufacturers to raise prices, wouldn't reference pricing in the home country make it worse for the foreign country? Not so! Although reference pricing reduces price in the home country, price in the foreign country remains the same. The manufacturer does have a strategic incentive to increase price in the foreign country to reduce competition in the home country, but there is a counteracting effect. All else equal, when price in the home country is reduced as a result of more intense competition, the manufacturer has an incentive to lower price in the foreign country as well, since reduced home price causes the demand for parallel import to fall.

Several implications follow from the result that price in the foreign country remains constant. As a direct consequence, the price of parallel imported drugs in the home country remains the same. Since marginal consumers buy parallel imports, whose price is constant, there will then be no decline in the share of prescriptions filled.

Introducing reference pricing would not even change the volume of parallel imports, because (i) the home-country consumer who is indifferent between the parallel imported drug and not consuming at all remains unaffected, as price in the foreign country (and thus price of the parallel import) stays the same, and (ii) the home-country consumer who is indifferent between the parallel imported and the locally-sourced drug also remains unaffected. Since the price of the locally sourced drug has fallen, one might have guessed that some consumers who had preferred the parallel import under coinsurance would now switch to the locally sourced drug. But it remains more expensive than the parallel import, and since consumers

are now paying the entire price difference out of their own pockets, there is a counteracting effect, and the two effects cancel each other out.

That the volume of parallel imports does not change with reference pricing has two implications: Further price reduction, in addition to that achieved under coinsurance, is achieved without using any additional resources for transportation, and the social cost incurred by the consumption of parallel imports does not rise. This cost accrues from the perception of parallel imports by some as inferior to locally sourced drugs because of their different packaging or labelling, even though they are therapeutically equivalent.

As a direct consequence of the results that price in the foreign country remains constant and that the volume of parallel imports does not change, foreign consumers are left unaffected by the policy change. So, contrary to intuition, parallel trade when combined with reference pricing – compared to coinsurance – need not harm foreign consumers. Thus reference pricing does not add to the beggar-thy-neighbour quality which parallel trade itself admittedly has even under coinsurance.

As the home-country consumer who is indifferent between the parallel imported and the locally sourced drug remains unaffected, the volume of locally sourced drugs consumed in the home country also does not change. This result, combined with the change in price, has implications for welfare. Although, everything else equal, the price of the locally sourced drugs has fallen, consumer surplus is unchanged, because the individuals who consume the locally sourced drug gain by paying a share of the price of the cheaper parallel import, but also lose by paying the full price difference. These two counteracting effects happen to be equal and offset each other. On the other hand, the monopolist incurs a profit loss due to the fall in the price of the locally sourced drug in the home country, which accrues as a gain to the public insurance, though aggregate welfare is unchanged in both the home and foreign country.

The next section presents the model in detail and solves for equilibrium conditions both under coinsurance and under reference pricing. The following section carries out a welfare analysis. The section after that performs robustness checks of the main results, followed by a section discussing price convergence and its components. Finally, the last section derives policy implications and conclusions.

The Model

I use Jelovac and Bordoy's (2005) two-country model with a price discriminating monopolist to analyze the effects of combining reference pricing with parallel trade. It is assumed that a pharmaceutical manufacturer supplies a certain patented drug, which is used in the treatment of a certain disease, in both home and foreign countries. Demand differs between the two countries due to (i) differing valuations due to different population characteristics and pervasiveness of the disease, and (ii) differing healthcare reimbursement policies. The monopolist manufacturer, therefore, price discriminates, selling the drug in the home and foreign countries at prices p and p^*. However, when parallel trade is legal, wholesalers in a perfectly competitive market can buy the drug in the low price country and sell it in the high price country. We assume that the parallel traders incur no other costs (e.g., transport costs). The marginal cost of production is assumed to be zero.

Individuals in each country can also differ in their valuation of the drug (v and v^*) depending on the severity of the disease and whether or not they have had the disease before.[10,11] We assume that the differing valuations among individuals in each country are distributed uniformly on the interval $[\underline{v}, \overline{v}]$ and $[\underline{v}^*, \overline{v}^*]$ where for simplicity $\overline{v} - \underline{v} = \overline{v}^* - \underline{v}^* = 1$.

As noted earlier, although there are no real differences between a parallel import and a locally-sourced drug – except that the parallel import is repackaged or relabelled – the parallel import is not considered to be a perfect substitute by consumers, and hence is valued less. The elderly, who may be used to one type of packaging, might even perceive them as inferior simply because they get confused by the differences in packaging. Evidence suggests that people are reluctant to switch medicines, even when they are therapeutically identical (Grabowski and Vernon, 1992; Frank and Salkaver, 1997). Consumers may also perceive parallel imports as inferior simply due to their lower price.[12] Thus we assume that consumers' gross valuations are deflated by a factor $\gamma \in (0,1)$ if they consume parallel imports, so that the

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[10] Following common notation in the international trade literature, variables pertaining to the foreign country are denoted by a superscript asterisk (*).

[11] Gaither et al. (2001) discuss surveys providing evidence on the influence of severity of a medical condition on the valuation of a drug.

[12] Medicines are credence goods, the utility of which is difficult for the consumer to ascertain. Consumers, then, tend to use price as an indicator of quality, considering the less expensive drug to be of poorer quality.

perceived quality difference between the parallel import and the locally-sourced drug is $(1-\gamma)$.

Individual drug expenditures are assumed to be subsidized by public insurance in each country. Basically, individuals pay a percentage (r) of the price in the home country and a percentage (r^*) of the price in the foreign country, where $r, r^* \in (0,1)$ and the rest $(1-r)$ and $(1-r^*)$ is paid by the public insurance in each country. In order to investigate the effects of parallel trade under differing healthcare reimbursement policies, we will analyze: unconditional reimbursement in the form of *coinsurance* versus conditional reimbursement in the form of *reference pricing*. The basic difference between the two policies is whether cost sharing is independent of the choice of drug. In coinsurance, consumers pay the same percentage of the price regardless of whether the more expensive locally-sourced drug or the parallel import is chosen. In reference pricing, on the other hand, consumers pay a percentage of the price of the cheaper parallel import (the reference drug), plus the price difference if they choose the more expensive locally-sourced drug.

Individuals in each country are assumed to have additively-separable utility in the consumption of a numeraire composite good and the drug. Each has an income y to buy the composite good and the drug. In autarky, when parallel trade is illegal, individuals in each country maximize utility by choosing either to consume one unit of the drug or none. When parallel trade is legal, however, consumers in the home country choose whether to consume one unit of the more expensive locally-sourced drug, or one unit of the cheaper parallel import, or none. For simplicity, the population of each country is normalized to 1.

We will analyse the implications of parallel trade under different reimbursement policies by studying strategic interactions among the pharmaceutical manufacturer, parallel traders, and consumers in a three-stage game. In the first stage, the manufacturer, acting as Stackelberg leader, sets the price in each country. In the second stage, parallel traders buy in the low-price foreign country and re-sell it in the high-price home country. In the third stage, individuals in the home country choose to consume either one unit of the locally-sourced drug, one unit of the parallel-imported drug, or nothing, and individuals in the foreign country choose to consume either one unit of locally-sourced drug, or nothing. The game is solved using backward induction.

We will start with investigating the benchmark case of autarky. Then we will analyze parallel trade (i) under coinsurance and (ii) under reference pricing.

Autarky – Parallel Trade Illegal

When parallel trade is illegal, the three-stage game, described above, boils down to a two-stage game. In the second stage, individuals in each country choose to consume one unit of the drug or nothing. Individuals are indifferent if the utility from consuming one unit of the drug, $\tilde{U}_l = \tilde{v} - rp$, is equal to the utility from not consuming at all, $U_0 = 0$, so that individuals with valuation $\tilde{v} \geq rp$ consume one unit of the drug. Home demand D is then

$$D = \begin{cases} 1 & if \quad p \leq \dfrac{\underline{v}}{r} \\[2mm] \overline{v} - r\,p & if \quad p \in \left] \dfrac{\underline{v}}{r}, \dfrac{\overline{v}}{r} \right[\\[2mm] 0 & if \quad p \geq \dfrac{\overline{v}}{r} \end{cases} \qquad \text{(Figure 1a)} \qquad \text{(Eq. 1)}$$

while foreign demand D^* is

$$D^* = \begin{cases} 1 & if \quad p^* \leq \dfrac{\underline{v}^*}{r^*} \\[2mm] \overline{v}^* - r^*\,p^* & if \quad p^* \in \left] \dfrac{\underline{v}^*}{r^*}, \dfrac{\overline{v}^*}{r^*} \right[\\[2mm] 0 & if \quad p^* \geq \dfrac{\overline{v}^*}{r^*} \end{cases} \qquad \text{(Figure 1b)} \qquad \text{(Eq. 2)}$$

Home Country
(a)
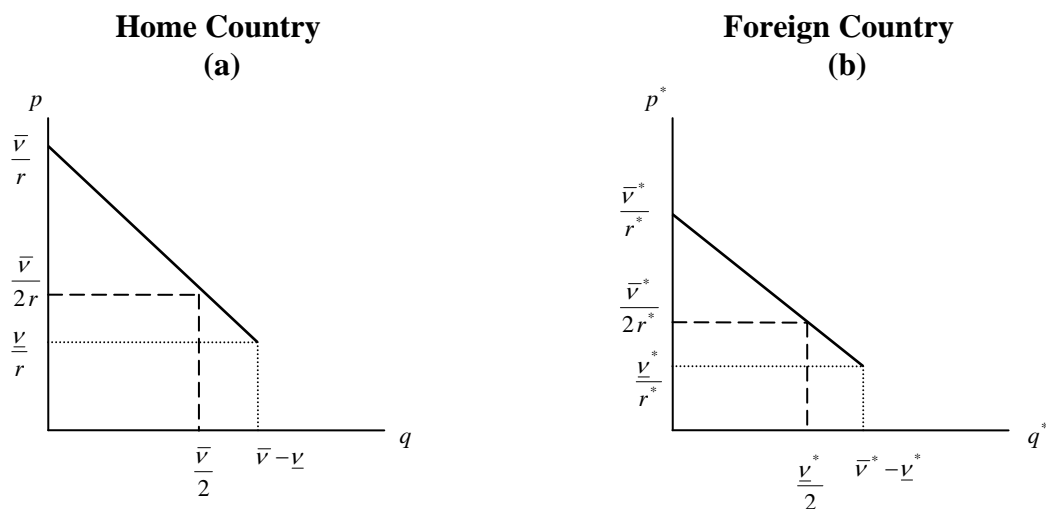
Foreign Country
(b)

Figure 1: Demand schedules in home and foreign countries

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Although a three-tier demand structure is defined, the analysis focuses on the second case where the market is partially covered, and the other two cases are ruled out. This is because the manufacturer won't charge prices lower than $\frac{v}{r}$ in the home country (Figure 1a) and $\frac{v^*}{r}$ in the foreign country (Figure 1b), since those would not be profit maximizing prices. Moreover, while there is evidence that demand for pharmaceuticals is inelastic, it is not perfectly inelastic (Ellison et al., 1997), so we can rule out the case where the monopolist charges a price equal to or less than $\frac{v}{r}$ and $\frac{v^*}{r}$. Hence, to get interior equilibrium solutions, we restrict the upper bounds $\bar{v}$ and $\bar{v}^*$ to vary within the range $[0, 2]$.

Given home and foreign demand, the manufacturer thus sets the price in each country that maximizes total profit

$$\Pi = p\,D + p^*\,D^* \qquad\qquad\qquad\qquad \text{(Eq. 3)}$$

Equilibrium prices are then

$$p = \frac{\bar{v}}{2r} \qquad\qquad\qquad\qquad \text{(Eq. 4)}$$

and

$$p^* = \frac{\bar{v}^*}{2r^*} \qquad\qquad\qquad\qquad \text{(Eq. 5)}$$

which are functions of the highest willingness to pay, and the coinsurance rate, in each country. At equilibrium, the more the consumers value the drug and the lower the coinsurance rate, the higher is the price the manufacturer charges. The coinsurance rate matters because, the less the consumers pay, the less price sensitive they are, and the less price elastic demand is.

Free Trade – Parallel Trade Legal

When parallel trade is legal, imports will flow from the low-price to the high-price country. We assume now (for the rest of the paper) that the two countries differ in such a way that the inequality $\frac{\bar{v}}{r} > \frac{\bar{v}^*}{r^*}$ holds. Given this assumption, the equilibrium price in the home country

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in autarky is higher than that in the foreign country. Parallel imports, therefore, will flow from the foreign country to the home country. In the third stage of the game, then, individuals in the home country choose to consume either one unit of locally-sourced drug, one unit of parallel import, or nothing. Individuals are indifferent between consuming one unit of parallel import or not consuming at all if the utility from consuming, $\tilde{U}_p = \gamma \tilde{v} - r p$, is equal to the utility from not consuming, $U_0 = 0$, such that

$$\tilde{v} = \frac{r p^*}{\gamma}$$

Similarly, individuals are indifferent between consuming one unit of locally-sourced drug or one unit of parallel import if the utility from the locally-sourced drug, $\hat{U}_l = \hat{v} - r p$, is equal to the utility from the parallel import, $\tilde{U}_p = \gamma \tilde{v} - r p$, such that

$$\hat{v} = \frac{r(p - p^*)}{(1 - \gamma)}$$

The choices of individuals with different valuations are described by the frequency function illustrated in Figure 2.
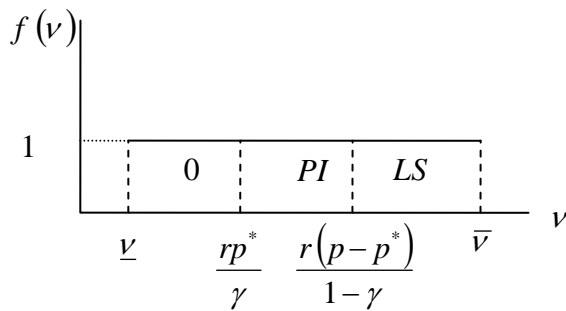

Figure 2: Frequency of valuations in the home country under coinsurance

Those with valuations higher than $\tilde{v} = \dfrac{r p^*}{\gamma}$ and lower than $\hat{v} = \dfrac{r(p - p^*)}{(1 - \gamma)}$ choose the parallel import, making its demand

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$$
D_{PI} = \begin{cases} 0 & \text{if} \quad p^* \geq \gamma\, p \\[2em] \dfrac{r\left(\gamma\, p - p^*\right)}{\gamma\left(1-\gamma\right)} & \text{if} \quad p^* < \gamma\, p \end{cases} \tag{Eq. 6}
$$

while those with higher valuations than $\hat{v} = \dfrac{r\left(p - p^*\right)}{\left(1-\gamma\right)}$ choose the locally-sourced drug, making its demand

$$
D = \begin{cases} \bar{v} - r\, p & \text{if} \quad p^* \geq \gamma\, p \\[2em] \bar{v} - \dfrac{r\left(p - p^*\right)}{1-\gamma} & \text{if} \quad p^* < \gamma\, p \end{cases} \tag{Eq. 7}
$$

Foreign-country individuals choose either consuming one unit of the drug or nothing. Demand in the foreign country is then

$$
D^* = \bar{v}^* - r^* p^* \tag{Eq. 8}
$$

Given these demands, the manufacturer sets the price in each country to maximize total profit

$$
\Pi = \left(\bar{v}^* - r^* p^*\right)p^* + \frac{r\left(\gamma\, p - p^*\right)}{\gamma\left(1-\gamma\right)} p^* + \left(\bar{v} - \frac{r\left(p - p^*\right)}{1-\gamma}\right)p \tag{Eq. 9}
$$

where the first term is revenue from sales for consumption in the foreign country; the second is revenue from sales in the foreign country for exports to the home country; and the third is revenue from sales of locally-sourced drug in the home country. Equilibrium prices are then

$$
p = \frac{\left(\gamma\left(1-\gamma\right)r^* + r\right)\bar{v} + \gamma\, r\, \bar{v}^*}{2r\left(\gamma\, r^* + r\right)} = \frac{\bar{v}}{2r} - \frac{\gamma\, r^*}{\gamma\, r^* + r}\left(\gamma\frac{\bar{v}}{2r} - \frac{\bar{v}^*}{2r^*}\right) \tag{Eq. 10}
$$

and

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$$p^* = \frac{\gamma(\overline{v}+\overline{v}^*)}{2(\gamma r^*+r)} = \frac{\overline{v}^*}{2r^*} + \frac{r}{\gamma r^*+r}\left(\gamma\frac{\overline{v}}{2r} - \frac{\overline{v}^*}{2r^*}\right) \tag{Eq. 11}$$

where $p = p^* + \dfrac{(1-\gamma)\overline{v}}{2r}$.

Because of the competition induced by parallel trade, price in the home country is lower than price in autarky, while price in the foreign country is higher (see Appendix A). This result confirms the common intuition, and the finding in the literature, that parallel trade leads to price convergence.

If (i) there are no trade costs; (ii) there is perfect competition among the parallel traders; and (iii) the parallel imported drugs are perceived as perfect substitutes for locally sourced drugs so that $\gamma=1$, then parallel trade leads to price equalisation across countries,

$$p = p^* = \frac{\overline{v}+\overline{v}^*}{2(r^*+r)}.$$

So far we have assumed that the manufacturer accommodates parallel trade because the two countries are not too different, such that $\lambda<\gamma$ where $\lambda=\dfrac{\overline{v}^* r}{\overline{v} r^*}$ is the measure of difference between them. However, the manufacturer wouldn't supply the foreign country, and thus deter parallel trade, if the two countries were quite different, such that $\lambda<\gamma\dfrac{1}{1+\sqrt{1+\dfrac{\gamma r^*}{r}}}$. The

manufacturer would then instead charge the autarky price in the home country, and would earn more profit.

Policy Change – Reference Pricing

Now let's consider a change in home-country healthcare reimbursement policy from *coinsurance* to *reference pricing*, under which drugs with the same active substance are grouped, and the price of the cheapest in each group is the reference which determines the level of reimbursement. The amount consumers pay, however, depends on which drug they buy. If they buy a parallel import they pay the coinsurance amount, and the rest is covered by

the public insurance. But if they buy the more expensive locally-sourced drug, they pay the same coinsurance amount plus the full price difference between the locally sourced-drug and the parallel import. We incorporate such conditional reimbursement into the model as follows:

If $\bar{p}$ is the reference price, then the co-payment c is

$$c = \begin{cases} r\,p & \text{if } p \le \bar{p} \\ r\,\bar{p} + (p - \bar{p}) & \text{if } p > \bar{p} \end{cases}$$

Only individuals with valuation

$$v \in \left[\frac{r\,p^*}{\gamma} ; \frac{p - p^*}{1 - \gamma} \right]$$

will consume the parallel import (Figure 3).
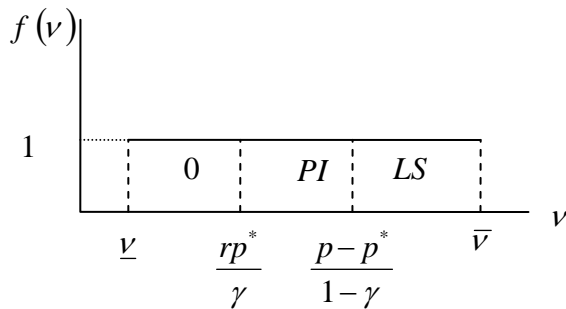

Figure 3: Frequency of valuations in the home country under reference pricing

Therefore demand for the parallel import in the home country is

$$D_{PI} = \begin{cases} 0 & \text{if } p^* > \dfrac{\gamma}{r(1-\gamma)+\gamma}\,p \\[3mm] \dfrac{\gamma(p - p^*) - (1-\gamma)(r\,p^*)}{\gamma(1-\gamma)} & \text{if } p^* \le \dfrac{\gamma}{r(1-\gamma)+\gamma}\,p \end{cases}$$

(Eq. 12)

The condition for parallel imports to be available in the home country is now less restrictive than under coinsurance (cf. Eq. 6) since

$$\frac{\gamma}{r(1-\gamma)+\gamma} > \gamma.$$

(Eq. 13)

This is why reference pricing promotes the use of parallel imports.

Home-country demand for the locally sourced drug is then

$$D = \begin{cases} \bar{v} - r\,p & \text{if} \quad p^* > \dfrac{\gamma}{r(1-\gamma)+\gamma}\,p \\[3mm] \bar{v} - \dfrac{p - p^*}{1-\gamma} & \text{if} \quad p^* \le \dfrac{\gamma}{r(1-\gamma)+\gamma}\,p \end{cases}$$

(Eq. 14)

while demand in the foreign country is

$$D^* = \bar{v}^* - r^*\,p^*$$

(Eq. 15)

Given these demands, the manufacturer sets price in each country to maximize total profits

$$\Pi_m = \left(D^* + D_{PI}\right)p^* + D\,p$$

$$= \left(\bar{v}^* - r^*\,p^* + \frac{\gamma\,p - [\gamma + (1-\gamma)r]\,p^*}{\gamma(1-\gamma)}\right)p^* + \left(\bar{v} - \frac{p - p^*}{1-\gamma}\right)p$$

(Eq. 16)

Subject to the condition in Eq. 13, equilibrium prices are then

$$p = \frac{\gamma\bar{v}^* + \left[(1-\gamma)(\gamma r^* + r) + \gamma\right]\bar{v}}{2(\gamma r^* + r)} = \Phi\frac{\bar{v}}{2r} - \frac{\gamma r^*}{\gamma r^* + r}\left(\gamma\frac{\bar{v}}{2r} - \frac{\bar{v}^*}{2r^*}\right)$$

(Eq. 17)

where $\Phi = 1 - (1-\gamma)(1-r)r$

and

$$p^* = \frac{\gamma\left(\overline{v}^* + \overline{v}\right)}{2\left(\gamma r^* + r\right)} = \frac{\overline{v}^*}{2r^*} + \frac{r}{\gamma r^* + r}\left(\gamma \frac{\overline{v}}{2r} - \frac{\overline{v}^*}{2r^*}\right)$$

which is same as Eq. 11, indicating that changing from coinsurance to reference pricing in the home country has not changed the price in the foreign country. However, because of increased competition induced by reference pricing, price in the home country is lower than under coinsurance.

Lemma I. For $v \sim U\left[\overline{v}, \underline{v}\right]$ and $v^* \sim U\left[\overline{v}^*, \underline{v}^*\right]$

such that $\overline{v} - \underline{v} = \overline{v}^* - \underline{v}^* = 1$; $\quad 0 \le \overline{v} \le 2$; $\quad 0 \le \overline{v}^* \le 2$; $\quad 0 \le \gamma \le \frac{p^*}{p}$; $\quad 0 \le r \le 1$; $\quad 0 \le r^* \le 1$:

$$p_{CI}^* = p_{RP}^* = \frac{\gamma\left(\overline{v}^* + \overline{v}\right)}{2\left(\gamma r^* + r\right)}$$

That is, price in the exporting country does not change.

This effect of changing from coinsurance to reference pricing in the home country is not in line with intuition. Since reference pricing is described as a policy promoting use of parallel imports, it might be expected intuitively that prices would converge more, rising in the foreign country due to increased demand while falling in the home country due to increased competition. A change to reference pricing in the home country does promote consumption of parallel import and thereby encourages parallel trade. As a result, demand in the foreign country increases, which is an incentive for the manufacturer to raise price. The manufacturer might even have another strategic motive to raise price in the foreign country, to increase the parallel traders' costs and thus reduce their sales.

The manufacturer, while increasing price in the foreign country strategically to deter parallel trade, correspondingly reduces price in the home country to compete with the cheaper parallel imported drugs. As a result, locally sourced drugs become relatively cheaper, while parallel imported drugs become relatively more expensive, which leads to a decrease in demand for parallel imports in the home country. The monopolist, then, would like to reduce the price in the foreign country.

So the change in price in the foreign country is the sum of attempts to deter parallel trade by increasing price, *the strategic effect*, and attempts to secure profits in the foreign country by decreasing price, *the competition effect*. These two effects are equal in absolute terms but opposite in sign, hence they cancel out each other and price in the foreign country stays the same.

Proposition I. Parallel trade under reference pricing, compared to under simple coinsurance – while leaving price in the foreign country unchanged since the strategic and competition effects cancel each other – causes price to fall in the home country.

Figure 4 shows these effects in terms of price reaction functions derived from conventional first-order profit maximization conditions. Each of the price reaction functions – represented by thin solid lines under coinsurance and by thick solid lines under reference pricing – defines the manufacturer's profit maximizing price in one country as a function of price in the other country under the alternative reimbursement systems. The reaction functions under coinsurance are

$$p_{CI}^{*}(p_{CI}) = \frac{\gamma(1-\gamma)\bar{v}^{*} + 2\gamma r\, p_{CI}}{2\left[\gamma(1-\gamma)r^{*} + r\right]}$$ (Eq. 18)

and

$$p_{CI}(p_{CI}^{*}) = \frac{(1-\gamma)\bar{v}}{2\,r} + p_{CI}^{*}$$ (Eq. 19)

while under reference pricing they are

$$p_{RP}^{*}(p_{RP}) = \frac{\gamma(1-\gamma)\bar{v}^{*} + 2\gamma\, p_{RP}}{2\left[(1-\gamma)(\gamma r^{*} + r) + \gamma\right]}$$ (Eq. 20)

and

$$p_{RP}(p_{RP}^{*}) = \frac{(1-\gamma)\bar{v}}{2} + p_{RP}^{*}$$ (Eq. 21)

As equations 18-19 and 20-21 indicate, under each of the alternative policies optimal price in one country is an increasing function of price in the other. The reaction function $p_{CI}^{*}(p_{CI})$ is

upward sloping because the monopolist charges a higher foreign price as the home price increases, to keep the price difference. Everything else equal, when the home price increases, the price difference becomes larger, making parallel trade more profitable, and driving increased imports to penetrate the home market more. As a result, price in the home country would fall even more, reducing the manufacturer's profit. Acting strategically, the manufacturer then raises the foreign price as well, as home price rises.

The reaction function $p_{RP}\left(p_{RP}^{*}\right)$ is also upward sloping because, the manufacturer charges a higher home price as the foreign price rises. A foreign price rise makes parallel imports more expensive in the home country, reducing demand for them, but increasing demand for locally-sourced drugs, which in turn induces the manufacturer to charge a higher price in the home country.

The reaction function $p_{CI}\left(p_{CI}^{*}\right)$ representing home price as a function of foreign price under coinsurance has the same slope as $p_{RP}\left(p_{RP}^{*}\right)$ under reference pricing and hence they are parallel to each other. On the other hand, the reaction function $p_{RP}^{*}\left(p_{RP}\right)$, representing foreign price as a function of home price under reference pricing, is not as steep as $p_{CI}^{*}\left(p_{CI}\right)$ under coinsurance (Appendix B.1 compares the slopes).
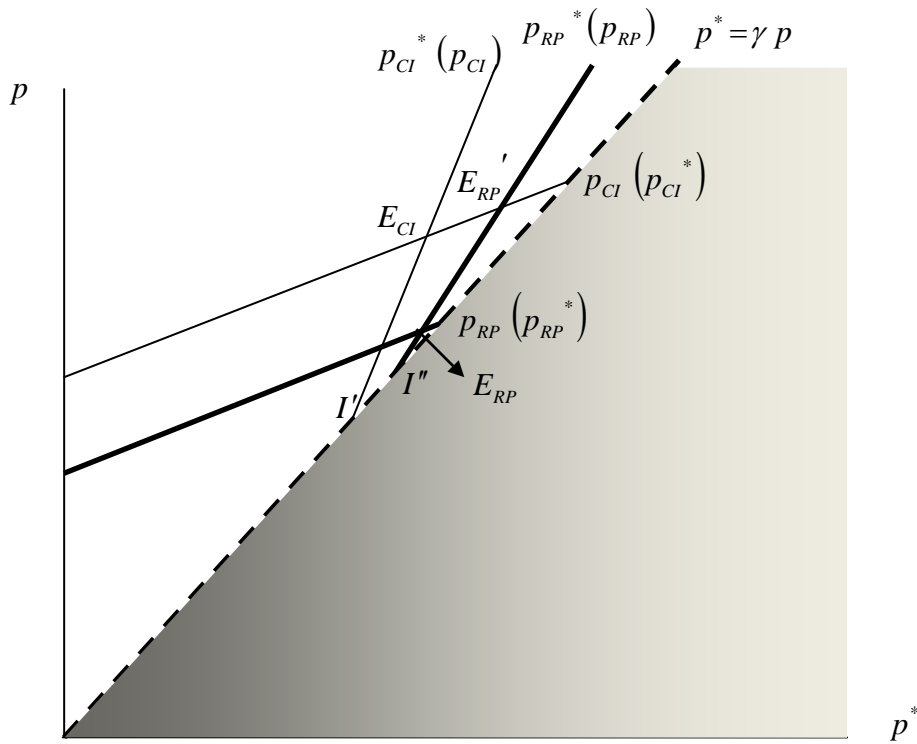
Figure 4: Strategic interaction and equilibrium prices after policy change from *coinsurance* **to** *reference pricing*

The line $p^* = \gamma p$, with intercept at the origin and lying above the 45^0 degree line – which represents equal home and foreign pricing – is the condition for parallel trade, where the price difference equals the amount by which consumers discount the parallel imported drug. Since parallel trade takes place when $p^* < \gamma p$, the relevant region for our analysis is left of the line. Equilibria under coinsurance and under reference pricing should occur in that region. Given the positions of the reaction curves, γ must be large enough that the line $p^* = \gamma p$ intersects $p_{CI}^*(p_{CI})$ at the point I' in the graph, below the point I'' where $p^* = \gamma p$ intersects $p_{RP}^*(p_{RP})$ (as shown in Appendix B.2). This is because – given the home-country price – the foreign price is higher under reference pricing than under coinsurance.

Equilibrium under coinsurance occurs at point E_{CI} where $p_{CI}^*(p_{CI})$ and $p_{CI}(p_{CI}^*)$ intersect. After the change from coinsurance to reference pricing, demand for parallel imports increases. The manufacturer then, acting strategically attempts to deter parallel trade by

increasing the foreign price. As a result $p_{CI}{}^*(p_{CI})$ shifts to the right under reference pricing to $p_{RP}{}^*(p_{RP})$, yielding the *strategic effect* represented by the move from E_{CI} to the new "equilibrium" at point $E_{RP}{}'$.

On the other hand, the greater availability of parallel imports in the home country triggers price competition, forcing the manufacturer to reduce the price of the locally sourced drug. As a result, $p_{RP}(p_{RP}{}^*)$ shifts downward to $p_{CI}(p_{CI}{}^*)$, resulting in a lower home country price for a given foreign price. As the locally-sourced drug becomes cheaper while the parallel import becomes more expensive, demand for the parallel import falls, forcing the manufacturer to reduce the foreign price. This yields the *competition effect* represented by the move from $E_{RP}{}'$ to the true equilibrium under reference pricing at point E_{RP}.

In sum, the manufacturer first strategically increases foreign price to deter trade, then reduces home price due to increased competition, which reduces demand for the parallel import and forces the foreign price to fall. The impact of reference pricing on the equilibrium price in the foreign country is thus the sum of (i) the strategic effect and (ii) the competition effect, which are equal in absolute value but differ in sign, and hence cancel out each other. As a result, the foreign price under reference pricing is the same as under coinsurance. It follows straightforwardly that

Proposition II. Parallel trade under reference pricing – compared to coinsurance – does not reduce the share of prescriptions filled.

Foreign price under reference pricing – and hence the price of parallel import – is the same as under coinsurance. The price for marginal consumers – who buy parallel imports in the home-country – is thus constant, so there is no change in the prescriptions filled.

Given the equilibrium prices, equilibrium quantities of parallel imports under reference pricing are also the same as under coinsurance.

Lemma II. For $v \sim U\left[\bar{v}, \underline{v}\right]$ and $v^* \sim U\left[\bar{v}^*, \underline{v}^*\right]$

such that $\bar{v} - \underline{v} = \bar{v}^* - \underline{v}^* = 1$; $0 \le \bar{v} \le 2$; $0 \le \bar{v}^* < 2$; $0 \le \gamma \le \dfrac{p^*}{p}$; $0 \le r \le 1$; $0 \le r^* \le 1$:

$$q_{CI} = q_{RP} = \frac{\gamma r^* \bar{v} - r \bar{v}^*}{2\left(\gamma r^* + r\right)}$$

That is, equilibrium quantities of parallel imports do not change.

It is then straightforward that

Proposition III. A change from coinsurance to reference pricing does not lead to any change in the social cost incurred because of the perceived quality differences between parallel imports and locally-sourced drugs.

Proof. Demand for the parallel import is $D_i = \hat{v}_i - c$ where $i = CI, RP$; $\hat{v}_i$ represents the valuation of an individual who is indifferent between the parallel import and the locally-sourced drug; and $c = \dfrac{r}{\gamma} p_i^*$ represents the valuation of a marginal individuals who are indifferent between consuming the parallel import and no drug at all. As has been shown, $p_{CI}^* = p_{RP}^*$, so c is constant regardless of coinsurance or reference pricing. Under the alternative policies,

$$\hat{v}_{CI} = \frac{r\left(p_{CI} - p_{CI}^*\right)}{1 - \gamma} \quad \text{(Figure 2)} \quad \text{and} \quad \hat{v}_{RP} = \frac{p_{RP} - p_{RP}^*}{1 - \gamma} \quad \text{(Figure 3)}$$

Changing from coinsurance to reference pricing does not change the volume of the parallel import for two reasons. First, the home-country consumer who is indifferent between the parallel import and no drug at all is unchanged, as the price in the foreign country, and thus the price of the parallel import, stays the same. Hence, as noted, c is constant. Second, the home-country consumer who is indifferent between the parallel import and the locally-sourced drug is also unchanged. This means the first term $(\hat{v}_i)$ of the demand function is the same under the two alternative policies. Since the price of the locally-sourced drug has fallen under reference pricing, one might have guessed that some consumers who preferred to buy the parallel import under simple coinsurance would switch to the locally-sourced drug, so that

$\hat{v}_{RP}$ would be larger than $\hat{v}_{CI}$. But the locally-sourced drug remains more expensive than the parallel import, and, since consumers are now paying the entire price difference, there is a countervailing effect. These two effects cancel, so that $\hat{v}_{RP} = \hat{v}_{CI}$.

Welfare Analysis

In a static partial-equilibrium framework, this section compares the welfare implications (changes in consumer surplus, manufacturer's profit, and public expenditure) of parallel trade combined with either coinsurance or reference pricing. We have seen that parallel trade reduces home price more under reference pricing than it does under coinsurance, while leaving foreign price unchanged. Hence, home-country consumers enjoy both decreased prices for the locally sourced-drugs and the alternative availability of cheaper parallel imports, while foreign consumers' prices do not change. This means that a change from coinsurance to reference pricing does not change consumer surplus in the foreign country, but home-country consumers pay a larger share of the price difference under reference pricing. So it is not clear whether the change improves consumer surplus in the home country. Moreover, savings accrue to the home-country government as public insurer, but manufacturer's profit is lower, due to increased competition in the home country. The overall welfare effect of the change is then not obvious.

Change in Consumer Surplus

As we have seen, changing from coinsurance to reference pricing does not change the price or the quantity of the parallel import (see Table I). The price of the locally-sourced drug in the home country has fallen, but home country consumers who consume it pay a larger share of the price difference out of their pocket. As a result, the change in consumer surplus in the home country is ambiguous. On the other hand, in the foreign country, since the price and the amount consumed stay the same, consumer surplus remains unchanged. So the change in global consumer surplus is determined by the change in the home-country consumer surplus, which is

$$\Delta CS = \int_{\hat{v}_{CI}}^{\bar{v}} (v - r\, p_{CI})\, dv - \int_{\hat{v}_{RP}}^{\bar{v}} \left(v - r\, p_{RP}{}^* - \left(p_{RP} - p_{RP}{}^* \right) \right) dv$$

$$= \frac{\bar{v}}{2} \left[\underbrace{r\left(p_{RP}{}^* - p_{CI} \right)}_{gain} + \underbrace{\left(p_{RP} - p_{RP}{}^* \right)}_{loss} \right] \qquad \text{(Eq. 25)}$$

$$= 0$$

The main determinants of the change in consumer surplus are the **gain** from paying a share of the price of the parallel import instead of the more expensive locally sourced drug and the **loss** incurred by paying the price difference. The gain and loss cancel each other, leaving consumer surplus unchanged.

Table 1: Equilibrium quantities demanded in home and foreign countries under coinsurance and reference pricing

	Coinsurance		Reference Pricing	
	Home Country	Foreign Country	Home Country	Foreign Country
Locally sourced	$\dfrac{\bar{v}}{2}$ (from Eq.7, Eq.9 & Eq.10)	$\dfrac{\bar{v}^*}{2} - \Lambda$ (from Eq.2 & Eq.10)	$\dfrac{\bar{v}}{2}$ (from Eq.14, Eq.16 & Eq.17)	$\dfrac{\bar{v}^*}{2} - \Lambda$ (from Eq.2 & Eq.17)
Parallel imported	$\Lambda = \dfrac{\gamma\, r^*\, \bar{v} - r\, \bar{v}^*}{2\left(\gamma\, r^* + r \right)}$ (from Eq.6, Eq.9 & Eq.10)		$\Lambda = \dfrac{\gamma\, r^*\, \bar{v} - r\, \bar{v}^*}{2\left(\gamma\, r^* + r \right)}$ (from Eq.12, Eq.16 & Eq.17)	
Total	$\dfrac{\bar{v}}{2} + \Lambda$	$\dfrac{\bar{v}^*}{2} - \Lambda$	$\dfrac{\bar{v}}{2} + \Lambda$	$\dfrac{\bar{v}^*}{2} - \Lambda$

Change in Manufacturer's Profit

Since foreign equilibrium price and quantity demanded (Table I) remain the same, manufacturer's profit from foreign sales does not change. However, the lower home price, with no change in quantity demanded, erodes profit. The fall in profit under reference pricing is

$$\Delta \Pi = \frac{\bar{v}}{2} \left(p_{CI} - p_{RP} \right) = -\frac{(1 - \gamma)(1 - r)\bar{v}^2}{4r} \qquad \text{(Eq. 26)}$$

Change in Public Expenditure

Since foreign equilibrium price and quantity demanded have not changed, the cost to the foreign public insurance has not changed either. However, since home equilibrium price has fallen with no change in quantity demanded in the home country, the cost to the home public insurance has fallen by

$$\Delta PE = \left(PE_{CI} - PE_{RP} \right)$$

where PE_{CI} stands for public expenditure under coinsurance, and PE_{RP} for that under reference pricing.

$$\Delta PE = \frac{\bar{v}}{2}(1-r)p_{CI} + \frac{\gamma\, r^*\,\bar{v} - r\,\bar{v}^*}{2\left(\gamma r^* + r\right)}(1-r)p_{CI}^{\;*} - \frac{\bar{v}}{2}(1-r)p_{RP}^{\;*} - \frac{\gamma\, r^*\,\bar{v} - r\,\bar{v}^*}{2\left(\gamma r^* + r\right)}(1-r)p_{RP}^{\;*} \quad \text{(Eq. 27)}$$

$$= \frac{\bar{v}}{2}(1-r)\left(p_{CI} - p_{RP}^{\;*}\right) \quad \text{(Eq. 28)}$$

The first two terms of Eq. 27 represent public insurance costs under coinsurance, accrued from consumption of the locally-sourced drug and the parallel import, respectively, while the last two represent the same under reference pricing.

Given that $p_{CI} = \dfrac{(1-\gamma)\,\bar{v}}{2r} + p_{CI}^{\;*}$ (Eq. 12) and $p_{CI}^{\;*} = p_{RP}^{\;*}$ (Lemma I)

then

$$\Delta PE = (1-\gamma)(1-r)\frac{\bar{v}^2}{4r} \quad \text{(Eq. 29)}$$

A change from coinsurance to reference pricing thus reduces public insurance costs because the home country government pays less to reimburse consumers' drug expenditures.

Change in Total Welfare

Whether total welfare (TW) has risen or fallen depends on the extent to which reduced public expenditure compensates for the loss in manufacturer's profit, where

$$\Delta TW = \Delta \Pi + \Delta PE$$

$$= -\frac{(1-\gamma)(1-r)\bar{v}^2}{4r} + \frac{(1-\gamma)(1-r)\bar{v}^2}{4r} \quad \text{(from Eq. 26, and 29)}$$

$$= 0$$

Thus total welfare does not change under reference pricing, which simply favours public insurance at the expense of manufacturer's profit. Hence, a change from coinsurance to reference pricing results in a transfer of wealth from the pharmaceutical manufacturer to public insurance.

Extensions – Robustness Check

This section performs a sensitivity analysis and checks whether the main implications of the model hold by

    I.   solving the model using a general rule of reference pricing defined as a weighted average of the home and foreign prices, such that

            $p_r = \beta\, p^* + (1-\beta)\,p$ where $0 < \beta < 1$; and

    II.   relaxing the assumptions

        (a) that income distribution is the same in each country and normalized to 1,

             $\bar{v} - \underline{v} = \bar{v}^* - \underline{v}^* = 1$, and

        (b) that market size in each country is normalized to 1.

Relaxing assumptions (a) and (b) allows the restrictive symmetric model used so far account for differences between the countries, which might enlighten the debate on parallel trade between, for example, the U.S. and Canada. Canadians might otherwise believe that, since they are a much smaller market, benefits will be biased towards the U.S.

I. Introducing a General Rule of Reference Pricing

The reference price in the home country can be defined more generally as a weighted average of the home price and the foreign price

$$p_r = \beta \, p^* + (1-\beta) p \text{ where } 0 < \beta < 1$$

Equilibrium prices are then

$$p^* = \frac{\gamma(\bar{v}^* + \bar{v})}{2(\gamma r^* + r)} \quad \text{and} \quad p = \frac{\gamma(\bar{v}^* + \bar{v})}{2(\gamma r^* + r)} + \frac{(1-\gamma)\bar{v}}{2[r + (1-r)\beta]}$$

As $\beta \to 1$ (i.e., as we approach the situation modelled earlier) competition increases and home price falls, since

$$\frac{\partial p}{\partial \beta} = -\frac{(1-\gamma)(1-r)\bar{v}}{2[r + (1-r)\beta]^2} < 0$$

When the model is solved using this general rule of reference pricing, the main implications of the model still hold, namely

- that parallel trade reduces home price more under reference pricing than under coinsurance, while leaving foreign price unchanged, and
- that changing from coinsurance to reference pricing does not change total welfare, though there is a transfer of wealth from the pharmaceutical manufacturer to the public insurer.

II. Relaxing Assumptions of Equal Income Distribution and Market Size

It is now assumed that both average income and distribution of income differ between the two countries so that $\bar{v} - \underline{v} \neq \bar{v}^* - \underline{v}^*$. Since consumers' valuations are shaped by their incomes, relaxing the assumption of equal distributions affects the demand functions and hence pricing in each country. In order to account for these differences we define

$$\begin{aligned} \bar{v} &= \mu + s \\ \underline{v} &= \mu - s \end{aligned} \quad \text{and} \quad \begin{aligned} \bar{v}^* &= \mu^* + s^* \\ \underline{v}^* &= \mu^* - s^* \end{aligned}$$

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where μ and μ^* represent average incomes, and s and s^* represent deviations from the means in the home and foreign country respectively

Equilibrium prices under coinsurance are

$$p_{CI} = \frac{\left(\gamma(1-\gamma)g\,r^*+r\right)\bar{v}+\gamma\,g\,r\,\bar{v}^*}{2\,r\left(\gamma\,g\,r^*+r\right)} \quad \text{and} \quad p_{CI}{}^* = \frac{\gamma\left(g\,\bar{v}^*+v\right)}{2\left(\gamma\,g\,r^*+r\right)}$$

where $g = \dfrac{s}{s^*}$ is the relative distribution of income in the home country.

Equilibrium prices under reference pricing are

$$p_{RP} = \frac{\gamma\,g\,\bar{v}^*+\left[(1-\gamma)\left(\gamma\,g\,r^*+r\right)+\gamma\right]\bar{v}}{2\left(\gamma\,g\,r^*+r\right)} \quad \text{and} \quad p_{RP}{}^* = \frac{\gamma\left(g\,\bar{v}^*+\bar{v}\right)}{2\left(\gamma\,g\,r^*+r\right)}$$

indicating that $p_{RP}{}^* = p_{CI}{}^*$ and that $p_{RP} < p_{CI}$.

Next it is assumed that market size differs between the two countries. Equilibrium prices under coinsurance are then

$$p_{CI} = \frac{\left(\gamma(1-\gamma)r^*+r\,m\right)\bar{v}+\gamma\,r\,\bar{v}^*}{2\left(\gamma\,r^*+r\,m\right)} \quad \text{and} \quad p_{CI}{}^* = \frac{\gamma\left(\bar{v}^*+\bar{v}\,m\right)}{2\left(\gamma\,r^*+r\,m\right)}$$

where $m = \dfrac{n}{n^*}$ stands for the relative market size of the countries.

Equilibrium prices under reference pricing are

$$p_{RP} = \frac{\gamma\,\bar{v}^*+\left[(1-\gamma)\left(\gamma\,r^*+r\,m\right)+\gamma\,m\right]\bar{v}}{2\left(\gamma\,r^*+r\,m\right)} \quad \text{and} \quad p_{RP}{}^* = \frac{\gamma\left(\bar{v}^*+\bar{v}\,m\right)}{2\left(\gamma\,r^*+r\,m\right)}$$

indicating that $p_{RP}{}^* = p_{CI}{}^*$ and that $p_{RP} < p_{CI}$.

Once again, when the model is solved allowing for differences in income distribution and market size, the main implications of the model still hold, namely

- that parallel trade reduces home price more under reference pricing than under coinsurance, while leaving foreign price unchanged, and

- that changing from coinsurance to reference pricing does not change total welfare, though there is a transfer of wealth from the pharmaceutical manufacturer to the public insurer.

Where Will Adjustment Take Place?

The common intuition is that parallel trade is triggered by the price difference between two countries, which determines the strength of competition and hence the amount of price convergence. But that initial price difference is not the only important factor for predicting the effects of parallel trade.

Price change under coinsurance in each country can be defined as a function of (i) the price difference in autarky, and (ii) the rate of convergence (Θ and Θ^*). The foreign price change is then

$$p_{CI}^* - p_A^* = \Theta^* \left(\gamma\, p_A - p_A^* \right) \quad \text{where} \quad \Theta^* = \left[\gamma\, \frac{r^*}{r} + 1 \right]^{-1} \tag{Eq. 22}$$

while the home price change is

$$p_{CI} - p_A = -\Theta \left(\gamma\, p_A - p_A^* \right) \quad \text{where} \quad \Theta = \left[\frac{1}{\gamma}\, \frac{r}{r^*} + 1 \right]^{-1} \tag{Eq. 23}$$

so that $\Theta + \Theta^* = 1$

The initial price difference must be measured using quality-adjusted prices. The rate of convergence (Θ) thus depend on the relative coinsurance rates and on the subjective value discount factor (γ). Given the initial price difference, the effect of parallel trade on foreign price will be larger

1. as the home coinsurance rate is larger than the foreign rate, i.e., as $r^* < r$, or

2. as home consumers perceive parallel imports to be poor substitutes for locally-sourced drugs, i.e., as γ diverges from unity.

Similarly, the effect on home price will be larger as $r < r^*$ and as γ converges towards unity. One might say that $\dfrac{r^*}{r}$ and γ determine in which country price will change more. If r^* is relatively large, home price will change more, foreign price will change less. Moreover, home price will change more, if γ is large.

Equation 22 implies that, given the initial price difference, foreign price increases more as the home coinsurance rate increases. Intuitively, when the home coinsurance rate increases, consumers pay more for drugs, so more opt for the cheaper parallel import. Hence, demand for the parallel import increases, allowing the manufacturer to charge a higher foreign price. On the other hand, home price falls more due to increased competition. Equation 23, however, contradicts this intuition, so one must understand why the initial prices are different when making predictions about the likely effect of parallel trade.

Consider the case of parallel trade between two North American countries, the USA and Canada, and between two European Union countries, Sweden and Greece. Assume that, before parallel trade is introduced, the price difference between the U.S. and Canada is the same as that between Sweden and Greece, with the price in the U.S. (Sweden) much higher than that in Canada (Greece). These two cases are illustrated in Figure 5, where $p_A\left(p_A^*\right)$ represents optimal autarky price in the U.S. (Sweden) and $p_A^*\left(p_A\right)$ represents optimal autarky price in Canada (Greece). One might expect price to fall a lot in the U.S. (Sweden) when parallel trade is allowed, but that is not necessarily the case. It depends why price was so high in the U.S. (Sweden) in the first place. It could be high because of a high valuation of the drug (which might be more likely in the U.S.) or because copayment is low (which might be more likely in Sweden).
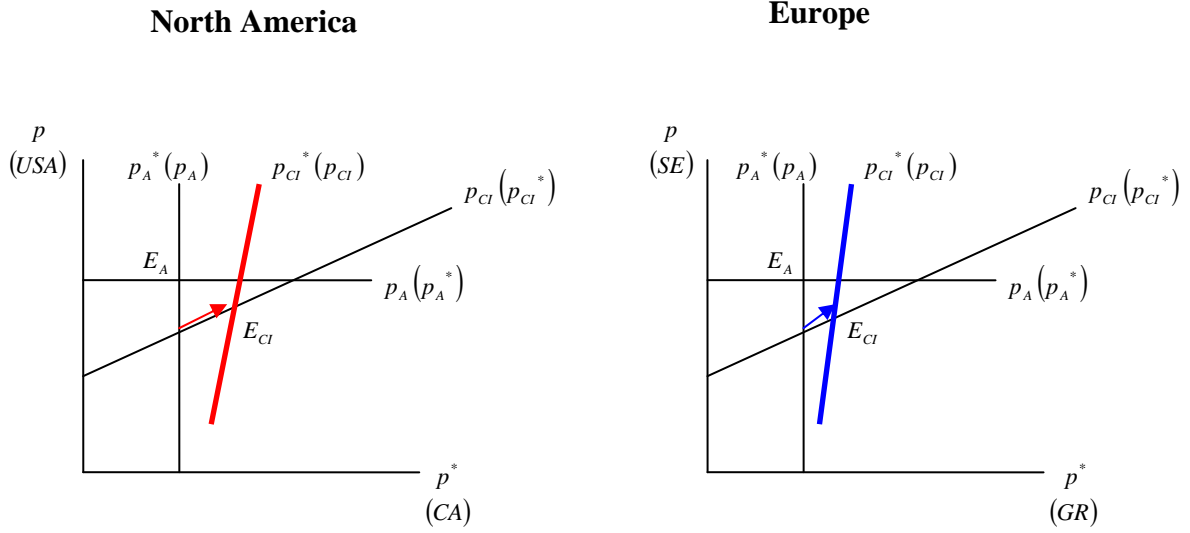
| North America | Europe |

Figure 5: Impact of parallel trade on price convergence

When parallel trade is allowed under coinsurance in both pairs of countries, price in the US (Sweden) goes down and price in Canada (Greece) goes up, but not necessarily equally across the pairs. Equilibrium occurs at E_{CI}, the intersection of $p_{CI}\left(p_{CI}^{*}\right)$ and $p_{CI}^{*}\left(p_{CI}\right)$. Although prices converge due to parallel trade in both cases, the amount of convergence differs. In North America, with a high coinsurance rate, parallel trade induces a lot of Americans to buy the drug in Canada. Therefore the manufacturer increases price in Canada more (due to both the normal commercial motives and the strategic response). This large price increase in Canada tends to lessen the price reduction in the U.S., represented by movement along $p_{CI}\left(p_{CI}^{*}\right)$, due to the complementarity of prices. One would then expect price in the U.S. to fall by less than in Sweden. Thus one has to be careful when making predictions, based on the European experience, about the likely price effect of parallel trade in North America.

Price convergence under reference pricing is defined as under coinsurance, but with an additional component of level effect, such that

$$p_{RP} - p_A = -\Theta\left(\gamma\, p_A - p_A^{*}\right) - (1-\gamma)(1-r)\, p_A \qquad \text{(Eq. 24)}$$

where the second term accounts for increased competition induced by reference pricing.

When the price convergence is further redefined under the assumption that average income and its distribution differ between the countries, it turns out that price convergence also depends on each country's income distribution, so that

$$p_{CI}^* - p_A^* = \Theta^* \left(\gamma \, p_A - p_A^* \right)$$

where the rate of convergence

$$\Theta^* \equiv \left[\gamma \frac{r^*}{r} \frac{S}{S^*} + 1 \right]^{-1} \in (0,1)$$

The rate of convergence thus depends on the relative coinsurance rates and on the relative income inequality in the two countries, but not on differences in average income. Taking the initial price difference as given, the effect on foreign prices will be smaller

1. as the home coinsurance rate is smaller than the foreign rate, or
2. as inequality in the home country is larger than that in the foreign country.

What does this say about the case of the U.S. and Canada? Probably the debate in Canada has focused on the observable and substantial price-difference between the two countries, perhaps causing a fear of large price increases. But convergence might be relatively modest since, although U.S. coinsurance rates are not on average so different from Canadian ones, income inequality is higher in the U.S. Consider the following example: If $\gamma = 0.9$, $r^*/r = 1.2$, and $S/S^* = 1.3$, Canadian price would increase by only 40% of the (quality-adjusted) price difference between the countries.[13]

Summary and Conclusions

How much do healthcare reimbursement policies affect the results of parallel trade? Policymakers allow parallel trade in order to increase competition and thereby reduce prices. However, if individuals are reluctant to buy parallel imports, or are price insensitive because of medical insurance, prices in the importing (home) country won't fall very much. On the other hand, consumers in the exporting (foreign) country might face higher prices or supply

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[13] The relative coinsurance rate is calculated as the ratio of share of per capita out-of-pocket payments in total health expenditures in Canada to that in the U.S. based on OECD figures for 2007. Relative income inequality is taken as the ratio of Gini coefficients in Picot and Myles (2005).

shortages, since manufacturers want to deter parallel trade. Besides, consuming parallel imports, which are perceived as inferior, creates a social cost of its own.

It has been shown here theoretically that parallel trade under reference pricing, compared to under coinsurance, can reduce home price while leaving foreign price unchanged, because strategic and competition effects counteract each other. The manufacturer has incentive to strategically increase foreign price to offset increased competition in the home country. But when home price falls as a result of more intense competition, the manufacturer also has incentive to lower the foreign price, since reduced home price causes the demand for parallel import to fall.

The fact that these two effects exactly offset each other is probably not a robust result, but they should be present even in a more general model. It is then an open question which effect would dominate, and whether foreign consumers might be hurt, or might benefit from reference pricing in the home country.

The fact that foreign price does not increase as a result of reference pricing has positive effects in the home country. The price of the parallel import remains the same. Since marginal consumers buy parallel imports, their price is constant, and hence there is no decline in the share of prescriptions filled.

Reference pricing does not change the volume of parallel imports, which has two implications. First, reference pricing does not increase the social cost incurred by the consumption of 'inferior" parallel imports. Second, price reduction is achieved without wasting any resources, for example in transportation costs.

As foreign price and volume of parallel imports remain constant after a change from coinsurance to reference pricing, foreign consumers are left unaffected. So, contrary to intuition, parallel trade when combined with reference pricing – compared to coinsurance – need not harm foreign consumers. Thus reference pricing does not add to the beggar-thy-neighbour quality which parallel trade itself admittedly has even under coinsurance.

A change from coinsurance to reference pricing is also found to result in a transfer of wealth from the pharmaceutical manufacturer to the public insurer, leaving global welfare

unchanged. Thus, reference pricing, as a cost containment policy, fulfils its task in reducing price and saving public expenditure.

Price change is not only a function of the initial (autarky) price difference, but also of a convergence factor, which depends on the relative coinsurance rate and on the extent to which consumers perceive the parallel import as a substitute for the locally-sourced drug. However, one, when making predictions about the likely price effect of parallel trade, needs to understand why prices were different between two countries in the first place.

These results may offer some insight to the ongoing debate whether the U.S. should allow parallel trade of pharmaceuticals from Canada. But if the U.S. healthcare system were restructured to be compatible with reference pricing, parallel trade – compared to what would be realized under simple coinsurance – could favour Americans without harming Canadians. However, as Kanavos and Reinhardt (2003) point out, it might be difficult for U.S. policymakers to decide how to introduce reference pricing, whether as a highly centralized system, or as a decentralized one with private insurers composing the groups of drugs and setting the reference prices. It might be equally difficult to decide how to form the groups of drugs: narrow clusters with the same active substance, or broad clusters with similar indication.

These results should be interpreted with caution, for several reasons. One is that pharmaceutical manufacturers do not set prices freely. Another is that, for strategic reasons, they may not supply all that is demanded at a given price. And a third is that government authorities might change the coinsurance rate when changing to reference pricing, which is the subject of further research.

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Appendix A: Equilibrium Prices in Autarky versus Parallel Trade

Compared to equilibrium prices in autarky, while foreign prices rise, home prices fall due to increased competition via parallel trade, by

$$\frac{\gamma(\bar{v}+\bar{v}^*)}{2(\gamma r^*+r)} - \frac{\bar{v}^*}{2r^*} = \frac{\gamma r^* \bar{v} - r\bar{v}^*}{2r^*(\gamma r^*+r)} > 0$$

$$\frac{\bar{v}}{2r} - \frac{(\gamma(1-\gamma)r^*+r)\bar{v}+\gamma r\bar{v}^*}{2r(\gamma r^*+r)} = \frac{\gamma(\gamma r^* \bar{v} - r\bar{v}^*)}{2r^*(\gamma r^*+r)} > 0$$

given $\gamma r^* \bar{v} > r\bar{v}^*$ which follows from the assumption that $\dfrac{\bar{v}}{r} > \dfrac{\bar{v}^*}{r^*}$ and the condition that $p^* < \gamma p$.

Appendix B.1: Comparison of the Slopes of $p_{CI}{}^*(p_{CI})$ and $p_{RP}{}^*(p_{RP})$

$$\frac{2\gamma r}{2[\gamma(1-\gamma)r^*+r]} < \frac{2\gamma}{2[(1-\gamma)(\rho r^*+r)+\gamma]}$$

$$\gamma(1-\gamma)r^* r + (1-\gamma)r^2 + \gamma r < \gamma(1-\gamma)r^* + r$$

$$(1-\gamma)r^2 + \gamma r - r < \gamma(1-\gamma)r^* - \gamma(1-\gamma)r^* r$$

$$(1-\gamma)r^2 - (1-\gamma)r < \gamma(1-\gamma)r^*(1-r)$$

$$-r(1-r) < \gamma r^*(1-r)$$

$$\gamma r^* + r > 0$$

So, $p_{CI}{}^*(p_{CI})$ is steeper than $p_{RP}{}^*(p_{RP})$.

Appendix B.2: Relative Positions of the Lines $p_{CI}{}^*(p_{CI})$ **and** $p_{RP}{}^*(p_{RP})$

Given $p^* = \gamma\, p$

Intersection of $p_{CI}{}^*(p_{CI})$ **with** $p^* = \gamma\, p$

$$p_{CI}{}^* = \frac{\gamma\,(1-\gamma)\bar{v}^* + 2\gamma\, r\, p_{CI}}{2\left[\gamma(1-\gamma)r^* + r\right]}$$

$$\gamma\, p_{CI} = \frac{\gamma\,(1-\gamma)\bar{v}^* + 2\gamma\, r\, p_{CI}}{2\left[\gamma(1-\gamma)r^* + r\right]}$$

$$2\gamma(1-\gamma)r^*\, p_{CI} + 2r\, p_{CI} = (1-\gamma)\bar{v}^* + 2\, r\, p_{CI}$$

$$2\gamma(1-\gamma)r^*\, p_{CI} = (1-\gamma)\bar{v}^*$$

$$p_{CI} = \frac{\bar{v}^*}{2\gamma\, r^*}$$

Intersection of $p_{RP}{}^*(p_{RP})$ **with** $p^* = \gamma\, p$

$$p_{RP}{}^* = \frac{\gamma\,(1-\gamma)\bar{v}^* + 2\gamma\, p_{RP}}{2\left[(1-\gamma)(\gamma\, r^* + r) + \gamma\right]}$$

$$\gamma\, p_{RP} = \frac{\gamma\,(1-\gamma)\bar{v}^* + 2\gamma\, p_{RP}}{2\left[(1-\gamma)(\gamma\, r^* + r) + \gamma\right]}$$

$$2\gamma(1-\gamma)r^*\, p_{RP} + 2\,(1-\gamma)r\, p_{RP} + 2\gamma\, p_{RP} = (1-\gamma)\bar{v}^* + 2\, p_{RP}$$

$$2\left[\gamma(1-\gamma)r^*\, p_{RP} + (1-\gamma)r\, p_{RP} - (1-\gamma)p_{RP}\right] = (1-\gamma)\bar{v}^*$$

$$2(1-\gamma)\left[\gamma\, r^* + r - 1\right]p_{RP} = (1-\gamma)\bar{v}^*$$

$$p_{RP} = \frac{\bar{v}^*}{2\left(\gamma\, r^* + r - 1\right)}$$

Note that $\gamma\, r^* + r > 1$

Since $\dfrac{\bar{v}^*}{2\gamma\, r^*} < \dfrac{\bar{v}^*}{2\left(\gamma r^* + r - 1\right)}$, $p_{CI}{}^*(p_{CI})$ intersects with $p^* = \gamma\, p$ at a point below where $p_{RP}{}^*(p_{RP})$ intersects with $p^* = \gamma\, p$.

Intersection of $p_{CI}{}^*(p_{CI})$ and $p_{RP}{}^*(p_{RP})$

$$\frac{\gamma\left(1-\gamma\right)\bar{v}^* + 2\gamma\, r\, p}{2\left[\gamma\left(1-\gamma\right)r^* + r\right]} = \frac{\gamma\left(1-\gamma\right)\bar{v}^* + 2\gamma\, p}{2\left[\left(1-\gamma\right)\left(\gamma r^* + r\right) + \gamma\right]}$$

$$\frac{\left(1-\gamma\right)\bar{v}^* + 2\, r\, p}{\gamma\left(1-\gamma\right)r^* + r} = \frac{\left(1-\gamma\right)\bar{v}^* + 2\, p}{\left(1-\gamma\right)\left(\gamma r^* + r\right) + \gamma}$$

$$\left(1-\gamma\right)\bar{v}^*\left[\gamma\left(1-\gamma\right)r^* + \left(1-\gamma\right)r + \gamma - \gamma\left(1-\gamma\right)r^* - r\right] =$$

$$2\, p\left[\gamma\left(1-\gamma\right)r^* + r - \gamma\left(1-\gamma\right)r^*\, r + \left(1-\gamma\right)r^2 + \gamma\, r\right]$$

$$\left(1-\gamma\right)\bar{v}^*\left[\left(1-\gamma\right)r + \gamma - r\right] = 2\left(1-\gamma\right)p\left[\gamma r^* - r\left(\gamma r^* + r\right) + r\right]$$

$$\bar{v}^*\left[r - \gamma\, r + \gamma - r\right] = 2\, p\left[\gamma r^* - r\left(\gamma r^* + r\right) + r\right]$$

$$p = \frac{\gamma\, \bar{v}^*\left(1 - r\right)}{2\left[\gamma r^* - r\left(\gamma r^* + r\right) + r\right]}$$

Besides, $p_{CI}{}^*(p_{CI})$ and $p_{RP}{}^*(p_{RP})$ intersect each other at point $\dfrac{\gamma\, \bar{v}^*\left(1 - r\right)}{2\left[\gamma r^* - r\left(\gamma r^* + r\right) + r\right]}$, denoted by A in Figure 4, which can be shown to lie below the point $\dfrac{\bar{v}^*}{2\gamma\, r^*}$.

$$\frac{\gamma \bar{v}^*(1-r)}{2\left[\gamma r^* - r(\gamma r^* + r) + r\right]} < \frac{\bar{v}^*}{2\gamma r^*}$$

$$\gamma^2 r^*(1-r) < \gamma r^* - \gamma r^* r - r^2 + r$$

$$\gamma^2 r^* - \gamma^2 r^* r < \gamma r^* - \gamma r^* r - r^2 + r$$

$$\gamma r^* r - \gamma^2 r^* r < \gamma r^* - \gamma^2 r^* - r^2 + r$$

$$\gamma r^* r(1-\gamma) < \gamma r^*(1-\gamma) + r(1-r)$$

$$\gamma(1-\gamma)r^*(1-r) + r(1-r) > 0$$

$$(1-r)\left(\gamma(1-\gamma)r^* + r\right) > 0$$