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COMPASSION AND COST:
The Dual Role of Reference Pricing

Miyase Yesim Köksal*

Abstract

Providing health insurance involves a trade-off between the benefits from risk spreading and the costs due to moral hazard. Focusing on pharmaceuticals consumption, this paper examines theoretically whether reference pricing, requiring individuals to pay the price difference if, in this case, they don't buy the cheaper parallel imported drug, can ease this trade-off – an issue which has not previously been pointed out in the debate on health insurance. The results indicate that, if individuals are extremely risk-averse, a policy shift from coinsurance to reference pricing would do this by providing more insurance while decreasing moral hazard.

JEL Code: F13, L12, I10, D82

Keywords: reference pricing, moral hazard, pharmaceuticals, parallel imports

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Introduction

Individuals cannot predict whether they will have a serious illness, or when; or whether it will disappear or recur, and how much medical treatment will cost. This inherent unpredictability of medical consumption is the reason for health insurance. However, if individuals were fully insured, they would over-consume, use more or prefer more costly, medical care, which raises moral hazard issues. For example, fully insured individuals would visit physicians more often, or would prefer more expensive brand-name drugs to cheaper alternatives: to generics, in the case of off-patent drugs, and to parallel imports in the case of on-patent drugs. Not only would individuals over consume (demand-side moral hazard), but healthcare providers and pharmaceutical producers would also overcharge (supply-side moral hazard), as a result of the distortion in price sensitivity caused by insurance.[1] Thus, insurers must trade off the benefits from more generous insurance - primarily the reduction in risk it affords – against the costs of more generous insurance - primarily moral hazard (Cutler and Zeckhauser, 1999).

Experimental studies conducted in various parts of the world (Namibia: Asfaw et al., 2008; Wuhan, China: Liu et al., 2007) found that individuals were willing to pay 5%-11% of their income for health insurance. Thus, on the one hand, individuals attach high value to health insurance. But, on the other hand, as the RAND Health Insurance Experiment (HIE) demonstrated, in the presence of generous health insurance they over-consume healthcare, resulting in welfare loss.[2] Per capita expenses on the free plan (no out-of-pocket costs) were 45% higher than those for the least generous cost-sharing plan, where individuals paid 95% of the costs (Manning et al., 1987). Based on HIE data, Manning and Marquis (1989) estimated that, when individuals paid only 1% instead of paying the full cost, moral hazard losses were more than twice the gains from risk-avoided (US$1596 vs. US$706 per family in 1988 dollars). More recently, Feldstein and Gruber (1994) estimated a potential $34 billion per year increase in aggregate welfare from switching to a modest health insurance.

[1] Feldstein (1973) shows that more insurance increases the price of care.
[2] The RAND Health Insurance Experiment, initiated in 1974 and completed in 1982, has been the only long-term experimental study of cost-sharing and its effect on service use, quality of care, and health.

Demand response to insurance-induced change in out-of-pocket cost has also been estimated focusing specifically on pharmaceuticals consumption. Insurance provides incentives for individuals to consume both more (Coulson and Stuart, 1995; Coulson et al., 1995; Rudholm, 2005; Costa-Font et al., 2007), and more expensive (Lundin, 2000), prescription pharmaceuticals. Lundin (2000) showed that patients getting most of their costs reimbursed were more likely to have more expensive brand-name drugs prescribed than patients paying a larger share of the cost.

Insurance has also been found to create moral hazard on the supply side: Pharmaceutical prices change significantly as a response to a change in health insurance (Pavcnik, 2002). When the cost is shared by the insurer, both individuals and physicians are less price-sensitive than they would otherwise be. As a result, demand is less price-elastic, and pharmaceutical producers naturally charge higher prices.

As evidenced, providing optimal health insurance involves a trade-off between the benefit from risk reduction and the cost of deleterious incentives. Thus, it is extremely important to find ways to ease this trade-off, “a happy compromise with some risk-spreading and some incentive” (Zeckhauser, 1970:10) for individuals to be cost-conscious in the purchase of healthcare. This paper demonstrates that reference pricing, a consumer-driven healthcare reimbursement policy, can provide just that – something that has not previously been pointed out in the debate.

To correct for the distortion in price-sensitivity caused by insurance and make individuals more price-sensitive, reference pricing has been introduced in many countries: Germany, Netherlands, Denmark, Sweden, Spain, Belgium, Italy, Poland, and Slovenia in Europe; also Canada (British Colombia), New Zealand, and Australia (Lopez-Casasnovas and Puig-Junoy (2000) review the variations in their practices). The common feature of these cost-containment policies is that pharmaceuticals are classified into groups with similar active ingredients or indications and a reference price is set for each group. If the price of a consumer-chosen product is higher than the reference price, then the consumer pays the price difference, so that they are more exposed to the “real” cost, reducing moral hazard. It has been shown empirically that such reference pricing increases consumer price-sensitivity and competition (Aronsson, Bergman and Rudholm, 2001; Pavcnik, 2002; Bergman and Rudholm, 2003; Brekke et al., 2008). It has also been shown theoretically that, under reference pricing, parallel trade of pharmaceuticals increases competition and decreases price more in the importing country than under coinsurance, where a flat percentage of the cost is paid by the consumer and the rest is paid by the insurer (Köksal, 2009). Although there are empirical and theoretical studies supporting policy change from coinsurance to reference pricing, the implications of reference pricing for the trade-off between risk pooling and moral hazard haven’t previously been discussed in the literature. Focusing specifically on pharmaceuticals consumption, this paper primarily attempts to fill this gap by examining theoretically whether reference pricing provides more insurance, while decreasing moral hazard.

A two country model of price differentiation is developed where a manufacturer produces a patented drug treating a certain disease, and supplies both countries. The two countries differ in terms of individuals’ valuations of the drug and in terms of the coinsurance rate, the percentage of the price consumer pays. Hence the manufacturer price differentiates between the two countries. Parallel trade is legal, so that parallel traders can buy the drug in the low-price (exporting, foreign) country and resell it in the high-price (importing, home) country. As a result, the drug is both locally sourced in the high-price country, directly from the manufacturer, and parallel imported from the low-price country.

Each individual faces the risk of getting sick with a certain probability. There are two types of individuals, high type (H-type), and low type (L-type) in the home country. Depending on their type, individuals have higher or lower severity of the disease. Sick individuals choose either the parallel imported or the locally sourced drug, given their prices and the coinsurance rate (the percentage of price paid out-of-pocket).

Although the two drugs are therapeutically equivalent, some might perceive the parallel import as inferior, since it is repackaged or relabeled by parallel traders. Differences in labeling might cause individuals to get confused and question the quality, safety and efficacy of the parallel imports. Apart from differences in packaging and labeling, differences in price might also affect individuals' quality expectations which in turn might influence therapeutic efficacy.[3] Waber et al. (2008) have clinically demonstrated this so called *placebo response* to lower prices.[4] Thus it is assumed in the model that both types value the locally sourced drug more than the parallel import, but H-types value both treatments more than do L-types.

The model is solved as a three stage game under two alternative healthcare reimbursement policies (i) coinsurance, and (ii) reference pricing. Although, reference pricing is structured differently from country to country, it is assumed that drugs therapeutically equivalent -with the same active substance in the same dosage form- are clustered together, and reference price is set equal to the price of the cheapest drug in the cluster. The timing of the game is as follows. First, the home-country government sets socially optimal coinsurance rate. Second, the manufacturer sets profit maximizing prices in the home and foreign countries. Third, individuals in the home-country choose which drug to consume, locally sourced or parallel import.

The results show that individuals are not fully insured under either policy. Under coinsurance, they pay a percentage of the cost and the rest is paid by the insurance. However, under reference pricing individuals are subsidized by an amount equal to a percentage of the price of the parallel imported drug regardless of their choice, and those who consume locally sourced drug in the optimum pay the price difference out of their pocket. The comparative risk analysis indicates that individuals are provided more insurance under reference pricing than they are under coinsurance. As a result, when individuals are extremely risk averse, reference pricing both corrects for the moral hazard problem and provides more insurance.

[3] Pharmaceuticals are credence goods about which individuals have no information. Lacking knowledge of a product, they tend to use price as an indicator of quality, that more expensive must be better.

[4] Waber et al. (2008) argue that "placebo responses" to commercial features may help explain why patients switching from branded medications may report that their generic equivalents are less effective. With reference to Waber et al. (2008), Sapone et al. (2009) claim that, paradoxically, the "conscious" choice of the generic drug, because of financial benefits, can "unconsciously" reduce its therapeutic efficacy.

The next section presents the model in detail and solves for optimal cost-sharing under coinsurance and under reference pricing. Then, the following section discusses the change in welfare caused by a policy shift from coinsurance to reference pricing. The section after that carries out a comparative risk analysis based on Rothschild and Stiglitz's (1970) definition of increasing risk. Finally, the last section derives policy implications and conclusions.

Model

In a two country model of price differentiation, a manufacturer is assumed to produce a patented drug, treating a certain disease, and to supply both countries. The manufacturer price discriminates, since the countries are assumed to differ in their valuations of the drug and the coinsurance rate. Parallel trade is assumed to be legal, so that parallel traders can buy the drug in the low price country (exporting foreign country) and resell it in the high price (importing home) country.

In the home country, there are two types of individuals, high type (H-type) with share α of the population, and low type (L-type) with share $1-\alpha$. Initially, both types are healthy, represented by a health stock of φ, which gets impaired when, with probability q, they become sick. H-types, in comparison to L-types, are assumed to be affected more severely, and hence have a lower health stock when sick. Then they have a health stock of φ_S^H, while L-types have a health stock of φ_S^L, such that $\varphi_S^H < \varphi_S^L < \varphi$. As treatment, sick individuals are assumed to choose either the locally sourced drug or, if available, the parallel imported drug. After treatment, an individual i's health status improves to φ_j^i where $i = H, L$ denotes individual's type and $j = A, B$ denotes the chosen drug, locally sourced or parallel imported.

Parallel imports are therapeutically equivalent to locally sourced drugs, with no real difference between them. However, they differ in packaging, since parallel imports are repackaged or relabelled by parallel traders before being sold in the home country. Differences in packaging and labelling might create uncertainty among consumers about the product's quality, safety and efficacy, possibly causing them to perceive parallel imports as inferior. Such concerns make them question the drug side effects and responsiveness. Apart from differences in packaging and labeling, differences in price might also affect individuals' quality-expectations, which can in turn influence therapeutic efficacy. Individuals might have placebo responses to lower prices, as clinically shown by Waber et al. (2008)[5], and might consider the parallel imported drug of low efficacy and hence value parallel imported drug less. Thus, it is assumed that both types prefer the locally sourced drug, valuing it more than the parallel import, so that $\varphi_B^H > \varphi_A^H$ and $\varphi_B^L > \varphi_A^L$. Moreover, since H-types are affected severely when sick, they value each treatment more than L-types do, implying that $\varphi_B^H > \varphi_B^L$ and $\varphi_A^H > \varphi_A^L$. It is also assumed that H-types gain not only higher total utility but also higher marginal utility than do L-types from consuming a locally sourced drug (the *single crossing property*), resulting in the following condition:

$$\varphi_B^H - \varphi_A^H > \varphi_B^L - \varphi_A^L$$

Both types are assumed to be covered by insurance with individuals paying an actuarially fair premium of p, which satisfies the zero profit condition for the insurers, and sharing the cost of treatment when sick.[6] Utility, then, depends on being healthy or sick; and, when sick, on whether treated by a locally sourced drug or a parallel imported drug. Individual i's state dependent utility is defined using the exponential utility function

$$V = -\exp\left(-\gamma U\left(r\right)\right)$$

where $U\left(r\right)$ is ordinal utility and γ is the coefficient of absolute risk aversion. Larger values of γ imply that individuals are more risk averse and thus willing to pay higher

[5] Waber et al. (2008) show that the discounted low-price medication was less effective than the regular price one.

[6] The insurance market is assumed to be perfectly competitive where insurance companies earn zero expected profits and charge actuarially fair premiums.

premiums for more generous heath insurance. Given exogenous income y, cardinal utility is then

$u = -\exp(-\gamma(y - p + \varphi))$ when individual i is healthy,

$u = -\exp(-\gamma(y - p + \varphi_S^i))$ when individual i is sick,

and

$u = -\exp(-\gamma(y - p - p_j + \varphi_j^i))$ when individual i is sick but treated by one of the drugs,

where p_j is the out-of-pocket cost of the chosen treatment, defined as a function of price c_j subject to the reimbursement policy.

Expected social utility is then

$$EU = -(1-q)\exp(-\gamma(y - p + \varphi)) - q\left[\alpha \exp\left(-\gamma\left(y - p - p_j + \varphi_j^H\right)\right) + (1-\alpha)\left(y - p - p_j + \varphi_j^L\right)\right]$$

which is a function of the probability of becoming sick and the choice of treatment when sick.

In the analysis, two alternative health care reimbursement policies (i) coinsurance, and (ii) reference pricing are considered. Under coinsurance, cost is shared, so that individuals pay a percentage (r_{CI}) of the price, and public insurance pays the rest, $(1 - r_{CI})$. Under reference pricing, however, individuals pay only a percentage (r_{RP}) of the price of the chosen drug if it is lower than the reference price, otherwise they pay the percentage of the reference price and the full price difference.

Given preferences, prices of the drugs, and reimbursement regime, either both types consume the same drug, or each type consumes a different drug in the optimum. Thus four cases – two pooling and two separating – are possible under each regime, namely: AA where both types consume the parallel imported drug; BB where both types consume the locally sourced drug; AB where H-types consume the locally sourced drug and L-types consume the parallel imported drug; and BA where H-types consume the parallel imported drug and L-types consume the locally sourced drug. But BA could never be optimal, since, everything else equal, given the single crossing property, a higher social welfare could always be attained by simply swapping drugs between two individuals of different types. The other three cases could each be optimal under certain conditions, which are defined solving the model as a three stage game. In the first stage, the public insurer sets the socially optimal coinsurance rate given the reimbursement policy. Then, in the second stage, the monopolist sets profit maximizing prices in each country taking the coinsurance rate as given. In the last stage, individuals choose one of the drugs given prices and the reimbursement policy. The game is solved using backward induction under both coinsurance and reference pricing.

If individuals were of one type, everyone would consume the same drug and everyone would be fully insured. A similar situation would arise if there were perfect information and individual types were known. However, since types are individuals' private information, the monopolist and the government induce individuals to reveal their type by self-selecting the appropriate drug. Hence, in each case, individuals' choices are determined by two constraints: the individual rationality constraint (IR), and the incentive compatibility constraint (*self-selection constraints*) (IC). First, each type, when sick, must want to consume a drug and be willing to pay the out of pocket cost $\left(p_j\right)$, so that they are at least as well off consuming the drug as not. Second, each type must prefer one drug to the other. Both types then consume parallel imports if

$$IR_A^L : \varphi_A^L - \varphi_S^L \geq p_A \qquad IC^L : \varphi_B^L - \varphi_A^L \leq p_B - p_A$$

and

$$IR_A^H : \varphi_A^H - \varphi_S^H \geq p_A \qquad IC^H : \varphi_B^H - \varphi_A^H \leq p_B - p_A$$

or both consume the locally sourced drug if

$$IR_B^L : \varphi_B^L - \varphi_S^L \geq p_B \qquad IC^L : \varphi_B^L - \varphi_A^L \geq p_B - p_A$$

and

$$IR_B^H : \varphi_B^H - \varphi_S^H \geq p_B \qquad IC^H : \varphi_B^H - \varphi_A^H \geq p_B - p_A$$

But if

$$IR_A^L : \varphi_A^L - \varphi_S^L \geq p_A \qquad\qquad IC^L : \varphi_B^L - \varphi_A^L \leq p_B - p_A$$

and

$$IR_B^H : \varphi_B^H - \varphi_S^H \geq p_B \qquad\qquad IC^H : \varphi_B^H - \varphi_A^H \geq p_B - p_A$$

then H-types consume the locally sourced drug while L-types consume the parallel import.

Since out of pocket cost (p_j) depends on the reimbursement policy, the model is solved first under coinsurance, and then, separately, under reference pricing.

Coinsurance

Under coinsurance, an individual pays a percentage (r_{CI}) of the price (c_j) of the chosen drug, and the rest is paid by public insurance. The out of pocket cost (p_j), is then

$$p_j = r_{CI}\, c_j \quad \text{where} \quad j = A, B$$

We solve the model starting from the third stage of the game, where individuals choose, given prices and coinsurance rate. Individuals of type i will choose a parallel import if consuming it makes them better off than not consuming at all, and if they prefer it to the locally sourced drug, so that

$$IR_A^i : \frac{\varphi_A^i - \varphi_S^i}{r_{CI}} \geq c_A \quad \text{and} \quad IC^i : \frac{\varphi_B^i - \varphi_A^i}{r_{CI}} \leq c_B - c_A$$

Similarly, individuals of type i will choose the locally sourced drug if consuming it makes them better off than not consuming at all, and if they prefer it to the parallel import, so that

$$IR_B^i : \frac{\varphi_B^i - \varphi_S^i}{r_{CI}} \geq c_B \quad \text{and} \quad IC^i : \frac{\varphi_B^i - \varphi_A^i}{r_{CI}} \geq c_B - c_A$$

The constraints that shape individuals' preferences are then

$$IR_A^L : \frac{\varphi_A^L - \varphi_S^L}{r_{CI}} \geq c_A \qquad IR_B^L : \frac{\varphi_B^L - \varphi_S^L}{r_{CI}} \geq c_B \qquad IC^L : \frac{\varphi_B^L - \varphi_A^L}{r_{CI}} \geq c_B - c_A$$

$$, \qquad\qquad \text{and}$$

$$IR_A^H : \frac{\varphi_A^H - \varphi_S^H}{r_{CI}} \geq c_A \qquad IR_B^H : \frac{\varphi_B^H - \varphi_S^H}{r_{CI}} \geq c_B \qquad IC^H : \frac{\varphi_B^H - \varphi_A^H}{r_{CI}} \geq c_B - c_A$$

Let, for simplicity, V_j^i denote the valuation of drug j by an individual of type i, so that $V_j^i = \varphi_j^i - \varphi_S^i$. Redefined accordingly, the constraints are then illustrated in Figure 1 to show the conditions under which both types consume the same drug (AA, BB); they consume different drugs (AB); only H-types consume a drug $(\Phi A, \Phi B)$; or neither consumes any drug $(\Phi\Phi)$.

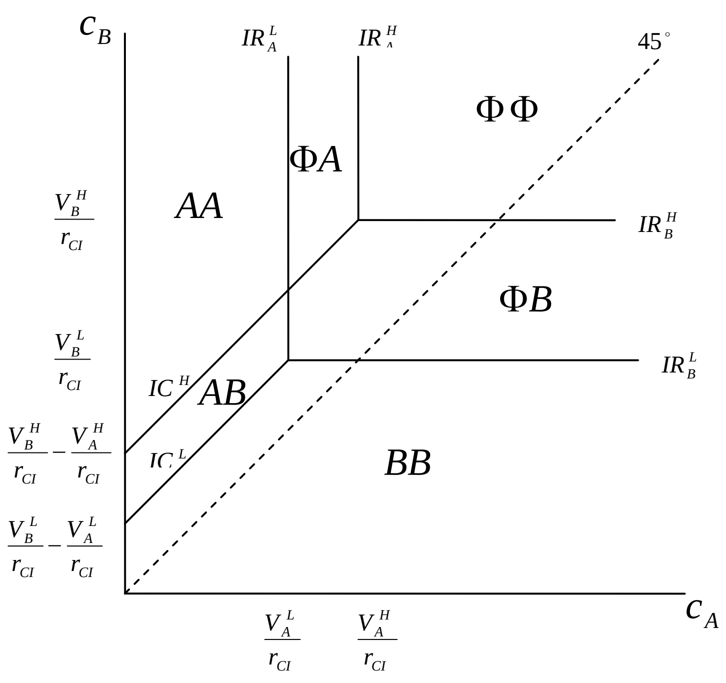

Figure 1. Individual rationality constraints, incentive compatibility constraints, and feasible allocations under coinsurance

Demand in the foreign country can be described by a negatively sloped demand function

$$D = v^{*} - r^{*} c_A$$

where v^{*} denotes the highest willingness to pay for the drug there, and r^{*} the rate of coinsurance.

In Autarky, when parallel trade is forbidden by law, the equilibrium price in the foreign country is then

$$c_A = \frac{v^{*}}{2r^{*}}$$

and assuming both types consume a drug, the equilibrium price in the home country is

$$c_B = \frac{\varphi_B^L - \varphi_S^L}{r_{CI}}$$

Suppose the two countries differ in such a way that the inequality $\frac{v^{*}}{2r^{*}} < \frac{\varphi_B^L - \varphi_S^L}{r_{CI}}$ holds, i.e., that the foreign price is lower than the home price. Then price in the home country is larger than that in the foreign country. Given sufficient price difference, if parallel trade is allowed, parallel traders in a perfectly competitive market can buy the drug in the foreign country and re-sell it in the home country. It is assumed that the home country is a small open economy such that it has no influence on the world prices and hence price in the foreign country stays the same when parallel trade is allowed. [7]

[7] If both types were to consume parallel imports in the home country, the monopolist profit would be then

$$\pi = M c_A + M^{*} \left(v^{*} - r^{*} c_A\right) c_A$$

where M represents the size of the home country market, and M^{*} that of the foreign country.
The profit maximizing equilibrium price of the parallel import would then be

$$c_A = \frac{1}{2mr^{*}} + \frac{v^{*}}{2r^{*}} \quad \text{where} \quad m = \frac{M^{*}}{M}$$ is the relative market size.

Even if both types prefer the locally sourced drug in equilibrium (i.e., BB), suppose some fraction epsilon (ε) amount of individuals always consume the parallel import. Although, demand in the out-patient market, which the analysis basically concerned with, is infinitesimal, the inpatient market (hospitals) creates a larger demand for parallel imports. So, given price difference, parallel imports are always available in the home country.

For the rest of the paper, we will assume that the inequality $\frac{v^*}{2r^*} \leq \frac{v_A^L}{r}$ holds, so that the IR constraint for L-types is fulfilled and both types consume a drug in the equilibrium. In addition, given the condition for parallel trade to take place, $c_A < c_B$, the relevant region for analysis is above the 45° line and left of the IR_A^L line in Figure 1, leaving three possibilities: AA, AB, or BB.

In the second stage of the game, given individual preferences', coinsurance rate and the price of the parallel import, the monopolist sets the profit maximizing price in the home country equal to

$c_B = \frac{\varphi_B^L - \varphi_A^L}{r_{CI}} + \frac{v^*}{2r^*}$ in the case of BB, which yields a profit of $\pi_{BB} = M\left[\frac{\varphi_B^L - \varphi_A^L}{r_{CI}} + \frac{v^*}{2r^*}\right]$

or

$c_B = \frac{\varphi_B^H - \varphi_A^H}{r_{CI}} + \frac{v^*}{2r^*}$ in the case of AB which yields a profit of

$$\pi_{AB} = M\left[\alpha\left(\frac{\varphi_B^H}{r_{CI}} - \frac{\varphi_A^H}{r_{CI}}\right) + \frac{v^*}{2r^*}\right]$$

If the home market is small compared to the foreign market, so that the term $\frac{1}{2mr^*}$ is negligible, then the equilibrium price in the foreign country is the same as in Autarky,

$$c_A = \frac{v^*}{2r^*}$$

The monopolist's profit is

$\pi_{AA} = M \dfrac{v^*}{2r^*}$ in the case of AA

AA cannot be optimal, since monopolist's profit in AA is less than in AB. Comparison of the corresponding profits indicates that either BB or AB would be optimal depending on the share of H-types.

Lemma I: If the share of H-types, α, is small, such that $0 < \alpha < \dfrac{\varphi_B^L - \varphi_A^L}{\varphi_B^H - \varphi_A^H}$, then the optimal price charged by the monopolist will be $c_B = \dfrac{\varphi_B^L}{r_{CI}} - \dfrac{\varphi_A^L}{r_{CI}} + \dfrac{v^*}{2r^*}$ and BB will be chosen. However, if α is large, such that $\dfrac{\varphi_B^L - \varphi_A^L}{\varphi_B^H - \varphi_A^H} < \alpha < 1$, then the optimal price charged by the monopolist will be higher, $c_B = \dfrac{\varphi_B^H - \varphi_A^H}{r_{CI}} + \dfrac{v^*}{2r^*}$ and AB will be chosen.

Given individuals' choices and optimal prices, in the first stage of the game, the home country government sets the optimal coinsurance rate that maximizes social welfare. Though a closed form solution cannot be derived for the coinsurance rate with either larger or smaller share of H-types, it is shown in Appendix A that, under a certain assumption, closed form solutions can be derived. If individuals are extremely risk averse, so that $\gamma \to \infty$, the government would set the optimal coinsurance rate to maximize the utility of the marginal individuals, L-types (the individuals with the lowest utility after treatment). As shown in Appendix A, this boils down to analytically assigning all the weight to the third term of the derivative of the welfare function, which can also be defined as a weighted average of the derivatives of utilities in various states. The results indicate that individuals will not be fully insured in equilibrium under coinsurance. They will pay a percentage of the price $r^* = \sqrt{\dfrac{q}{1-q} \dfrac{\varphi_B^L - \varphi_A^L}{c_A}} > 0$ in the case of BB, and $r^* = \sqrt{\alpha \dfrac{q}{1-q} \dfrac{\varphi_B^H - \varphi_A^H}{c_A}} > 0$ in the case of AB. Individuals pay a smaller share in the case of BB, when H-types are fewer, than they do in the case of AB. Although both types consume the locally sourced drug in the case of BB, they are not fully insured. The reason is that the monopolist would then charge a higher price, since individuals would be less price elastic.

Reference Pricing

Suppose the home country government changes the reimbursement policy from coinsurance to reference pricing where the parallel import determines the reference price for the locally sourced drug. An individual pays only a percentage (r_{RP}) of the price of parallel import, plus the full price difference if choosing the more expensive locally sourced drug. The out of pocket cost, then, is

$$p_j = \begin{cases} r_{RP}\, c_A & \textit{if parallel import is chosen} \\ r_{RP}\, c_A + (c_B - c_A) & \textit{if locally sourced drug is chosen} \end{cases}$$

As in the previous section, the model is solved starting from the third stage of the game where individuals make their choices. Individual of type i will choose the parallel import if consuming it makes them better off than not consuming, and if they prefer it to the locally sourced drug, so that

$IR_A^i : \varphi_A^i - \varphi_S^i \geq r_{RP}\, c_A$ and $IC^i : \varphi_B^i - \varphi_A^i + c_A \leq c_B$

Similarly, individuals of type i will choose the locally sourced drug if consuming it makes them better off than not consuming, and if they prefer it to the parallel import, so that

$IR_B^i : \varphi_B^i - \varphi_S^i + (1 - r_{RP})c_A \geq c_B$ and $IC^i : \varphi_B^i - \varphi_A^i + c_A \geq c_B$

The constrains that shape individuals' preferences are then

$$IR_A^L : \varphi_A^L - \varphi_S^L \geq r_{RP}\, c_A \qquad IR_B^L : \varphi_B^L - \varphi_S^L + (1 - r_{RP})c_A \geq c_B \qquad IC^L : \varphi_B^L - \varphi_A^L + c_A \geq c_B$$

, and

$$IR_A^H : \varphi_A^H - \varphi_S^H \geq r_{RP}\, c_A \qquad IR_B^H : \varphi_B^H - \varphi_S^H + (1 - r_{RP})c_A \geq c_B \qquad IC^H : \varphi_B^H - \varphi_A^H + c_A \geq c_B$$

As before let, for simplicity, V_j^i denote the valuation of drug j by an individual of type i, so that $V_j^i = \varphi_j^i - \varphi_S^i$. Redefined accordingly, the constraints are then illustrated in Figure 2 to show the conditions under which both types consume the same drug (AA, BB); they consume different drugs (AB); only H-types consume a drug $(\Phi A, \Phi B)$; or neither consumes any drug $(\Phi\Phi)$.

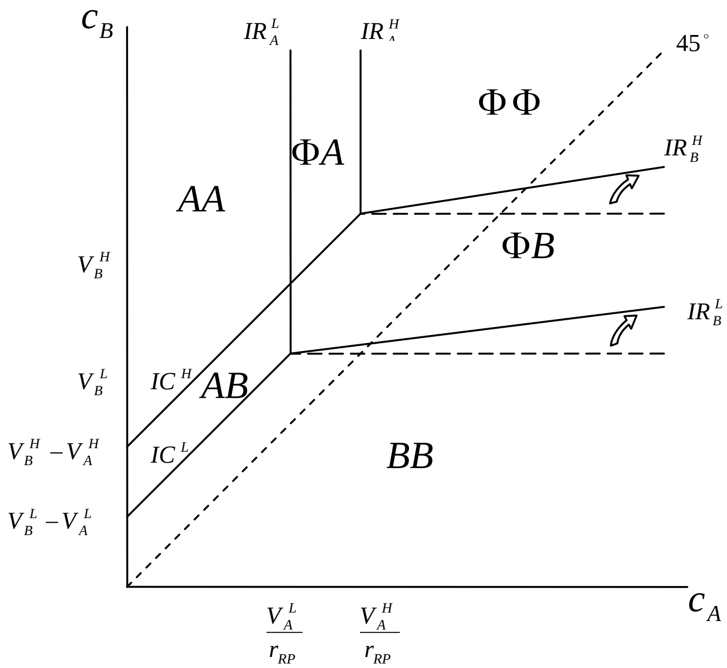

Figure 2. Individual rationality constraints, incentive compatibility constraints, and feasible allocations under reference pricing

The individual rationality constraints for consuming parallel imports (IR_A^i) remain the same under reference pricing. However, the individual rationality constraints for consuming the locally sourced drug (IR_B^i) change slope as indicated by the arrows, and become steeper while the incentive compatibility constraints shift upwards without any change in slope.

Similar to the analysis under coinsurance, given the inequality $\frac{v^*}{2r^*} \le \frac{v_A^L}{r}$ and the condition for parallel trade to take place, $c_A < c_B$, the relevant region for analysis is above the 45° line and left of the IR_A^L line in Figure 2, leaving three possibilities; AA, AB, and BB.

In the second stage of the game, given the individuals' preferences, the coinsurance rate and the price of the parallel import, the monopolist sets the profit maximizing price in the home country equal to

$c_B = \varphi_B^L - \varphi_A^L + \frac{v^*}{2r^*}$ in the case of BB, which yields a profit of $\pi_{BB} = M\left[\varphi_B^L - \varphi_A^L + \frac{v^*}{2r^*}\right]$

or

$c_B = \varphi_B^H - \varphi_A^H + \frac{v^*}{2r^*}$ in the case of AB, which yields a profit of $\pi_{AB} = M\,\frac{v^*}{2r^*}$

The monopolist's profit in the case of AA is

$$\pi_{AA} = M\left[\alpha\left(\varphi_B^H - \varphi_A^H\right) + \frac{v^*}{2r^*}\right]$$

Again, AA cannot be optimal, since monopolist earns less in AA than in AB. Comparison of monopolist's profits indicates that either BB or AB would be optimal, depending again on the share of H-types.

Lemma II: If the share of H-types, α, is small, such that $0 < \alpha < \frac{\varphi_B^L - \varphi_A^L}{\varphi_B^H - \varphi_A^H}$, then the optimal price charged by the monopolist will be $c_B = \varphi_B^L - \varphi_A^L + \frac{v^*}{2r^*}$ and BB will be chosen. However, if α is large, $\frac{\varphi_B^L - \varphi_A^L}{\varphi_B^H - \varphi_A^H} < \alpha < 1$, then the optimal price charged by the monopolist will be higher, $c_B = \varphi_B^H - \varphi_A^H + \frac{v^*}{2r^*}$ and AB will be chosen.

The condition for optimal allocation in both cases (BB and AB) is independent of the rate of coinsurance which means that the government's choice of optimal cost sharing has no effect on the optimal allocation.

The price charged by the monopolist under reference pricing is lower than under coinsurance, due to increased competition. Although one might expect the price under reference pricing to be higher than that under no-insurance (or self-insurance), as shown in Köksal (2009), the price under reference pricing, in the present model, happens to be the same as what would be charged then. This means that reference pricing corrects totally for the supply-side moral hazard induced by insurance.

Given individuals' preferences and optimal prices, in the first stage of the game, the home country government sets the optimal coinsurance rate that maximizes social welfare. Appendix B shows that, in both cases (BB and AB) individuals, if extremely risk averse, will be subsidized by an amount equal to a percentage of the price of the parallel import, regardless of their choice. However, those who choose locally sourced drug will pay the price difference.

Will Everyone be Better-off?

An interesting question is whether everyone will be better off after a switch from coinsurance to reference pricing. The answer is not obvious, since both the premium and the out-of-pocket cost of the drug change (see Table 1). Both change since they are functions of the price and the coinsurance rate, both of which change as a result of the policy shift. When reference pricing is introduced, the price of the locally sourced drug falls due to increased competition. However, the change in the premium is not that clear-cut, since both the price and the coinsurance rate have changed. But we can compare total cost (out-of-pocket cost plus the premium paid) under coinsurance with that under reference pricing for both types. The comparisons (in Appendix C) indicate that, in both cases if the probability of getting sick is small, then all sick individuals will be better off under reference pricing. Assuming that there is no cash payment under reference pricing, i.e., that the optimal coinsurance rate is zero, healthy people will also be better off. As a result, given that individuals get sick with a small probability, a policy shift from coinsurance to reference pricing would make all individuals better off.

Table 1. Costs of and benefits from various allocations for H-types and L-types under coinsurance and reference pricing

			Cost	**Benefit**
Coinsurance	BB	L-Type	$p_{CI} + r_{CI}\, c_B$	φ_B^L
		H-Type	$p_{CI} + r_{CI}\, c_B$	φ_B^H
	AB	L-Type	$p'_{CI} + r'_{CI}\, c_A$	φ_A^L
		H-Type	$p'_{CI} + r'_{CI}\, c'_B$	φ_B^H
Reference Pricing	BB	L-Type	$p_{RP} + r_{RP}\, c_A + (c_B - c_A)$	φ_B^L
		H-Type	$p_{RP} + r_{RP}\, c_A + (c_B - c_A)$	φ_B^H
	AB	L-Type	$p'_{RP} + r'_{RP}\, c_A$	φ_A^L
		H-Type	$p'_{RP} + r'_{RP}\, c_A + (c'_B - c_A)$	φ_B^H

“More Insurance” under Reference Pricing

The analyses under coinsurance and reference pricing have shown that (i) individuals will not be fully insured under either policy; (ii) under coinsurance, they pay a percentage of the price of the chosen drug; (iii) under reference pricing, they are paid cash back equal to a percentage of the price of the parallel imported drug regardless of choice but asked to pay the price difference out-of-their pocket if they choose to consume locally sourced drug. Since the cost-sharing rule and the price of the locally sourced drug have both changed because of the policy shift, the out-of-pocket cost may differ under the two policies. But whether the policy shift will provide more or less insurance is still an open question.

Health insurance helps individuals avoid risk of financial loss in case of illness. More insurance lets individuals enjoy greater risk-avoidance. A natural measure of change in insurance provided thus depends on the change in risk avoided. If insurance pays more of the cost, individuals face less risk of financial loss. The share of cost paid by insurance can thus be used as a measure of riskiness. The analysis indicates that, in both cases (BB and AB) the share of cost paid by insurance is larger under reference pricing than it is under coinsurance.

Proposition I. If individuals are extremely risk averse, then a policy shift from coinsurance to reference pricing will correct for moral hazard and provide individuals with more insurance.

Proof. In the case of BB, the share of cost paid by insurance is $\frac{q(1-r_{CI})c_B}{q\,c_B}$ under coinsurance, and $\frac{q(1-r_{RP})c_A}{q\,c_B}$ under reference pricing. In the case of AB, it is $\frac{q[\alpha(1-r_{CI})c_B+(1-\alpha)(1-r_{CI})c_A]}{q[\alpha\,c_B+(1-\alpha)c_A]}$ under coinsurance, and $\frac{q(1-r_{RP})c_A}{q[\alpha\,c_B+(1-\alpha)c_A]}$ under reference pricing.

Given optimal cost sharing under the assumption of extreme risk aversion ($\gamma\to\infty$), the share of cost paid by the insurer is larger under reference pricing than under coinsurance in the case of BB since

$$-\sqrt{\frac{q}{1-q}\frac{\varphi_B^L-\varphi_A^L}{c_A}}<1+\frac{\varphi-\overline{\varphi}_B}{\varphi_B^L-\varphi_A^L+c_A}$$

and in the case of AB since

$$1-\sqrt{\frac{q}{1-q}\frac{\varphi_B^L-\varphi_A^L}{c_A}}<\frac{c_A+\varphi-\overline{\varphi}_A}{\alpha\left(\varphi_B^H-\varphi_A^H\right)+c_A}.$$ [8]

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[8] As $\varphi>\varphi_B^H$ and $\varphi_A^H>\overline{\varphi}_A$, $c_A+\varphi-\overline{\varphi}_A>\alpha\left(\varphi_B^H-\varphi_A^H\right)+c_A$, and hence $\frac{c_A+\varphi-\overline{\varphi}_A}{\alpha\left(\varphi_B^H-\varphi_A^H\right)+c_A}>1$

As a result, a policy shift from coinsurance to reference pricing would smooth the trade-off between risk spreading and possible perverse incentives provided. It would both provide more insurance and correct for moral hazard.

A more founded approach to comparing risk is to use the Rothschild and Stiglitz's classic (1970) characterization of "increasing risk". They showed that, of two random variables with the same mean, the one with more weight in the tails is more risky. They say:

If X and Y have density functions f and g, and if g was obtained from f by taking some of the probability weight from the centre of f and adding it to each tail of f, in such a way as to leave the mean unchanged, then it seems reasonable to say that Y is more uncertain than X. (Rothschild and Stiglitz, 1970)

In the model here, income equivalent when healthy or sick under each reimbursement policy can be represented by a discrete variable, F_{CI} under coinsurance and F_{RP} under reference pricing, each taking three values with certain probabilities (Table D2 in Appendix D). Since means of these two discrete variables differ, we cannot directly apply the Rothschild and Stiglitz definition. In order to use it, we first introduce a sequence of mean preserving spreads, $\tilde{G}$ and $\tilde{\tilde{G}}$. Expected income equivalence is higher under reference pricing than under coinsurance (see Appendix D) by

$$\Delta = q\alpha \frac{1-r_{CI}}{r_{CI}}\left(\varphi_B^H - \varphi_A^H\right)$$

A discrete variable $\tilde{G}$ is constructed by taking Δ amount of money from everybody and giving it away such that the mean of $\tilde{G}$ is the same as the mean of F_{CI}. Since the same amount of money is taken from everyone, F_{RP} and $\tilde{G}$ don't differ in terms of risk.[9] Using the sequence of mean preserving spreads, it is shown in Appendix D that $\tilde{G}$ and

[9] More specifically, they cannot be compared in terms of risk, and they have the same risk.

F_{CI} have the same mean, but $\tilde{G}$ has less weight in the tails, and is thus less risky. By transitivity, F_{RP} is less risky than F_{CI}, meaning that more insurance is provided under reference pricing.

Conclusion

This paper has examined how the introduction of healthcare reimbursement policy of reference pricing for pharmaceuticals might affect the level of medical insurance. By covering part of the cost, insurance enables individuals to buy and consume drugs prescribed by their doctors, while reducing variations in real income between sick and healthy people. The drawback is moral hazard. With insurance, people become less price-sensitive and may choose more expensive drugs over cheaper but therapeutically equivalent alternatives. For example, people may continue to buy brand name or locally sourced drugs over generics or parallel imports. As a result, pharmaceutical companies have little reason to compete in prices, leading to higher costs for society. Reference pricing means that the insurance only covers part of the cost of the cheapest alternative among a set of drugs considered therapeutically equivalent. If one buys a more expensive alternative, one has to pay the full *extra* cost.

Reference pricing has previously been shown to reduce moral hazard arising from medical insurance. Introducing reference pricing, consumer price-sensitivity increases, competition increases, and the prices of drugs fall. The main contribution of the current paper is to point out, and to demonstrate, that reference pricing also eases the trade-off between proper incentives and the demand for insurance. With reference pricing, the optimal amount of medical insurance will be higher.

The results of this normative analysis might add a new insight to the ongoing debate about healthcare reform in the US, aimed at controlling costs and increasing health insurance. The reform proposes subsidies and regulation to provide more insurance, and possibly a “medicare” style public health insurance plan to create competition in the insurance market and thereby decrease cost. Although they seem like opposing alternatives, Paul Krugman stated in his New York Times column on July 24, 2009 "when it comes to reforming health care, compassion and cost-effectiveness go hand in hand." If U.S. health insurance plans were restructured to be compatible with reference pricing, they would have a stake in achieving the two goals, controlling healthcare costs and increasing health insurance at the same time.

Nevertheless, the results here should be interpreted with some caution, due to limitations of the model, which does not account for the effect of income on demand for pharmaceuticals. It also does not allow for individuals who cannot afford any drug. And the results hold when individuals are extremely risk averse.

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Appendix A. The Optimal Rate of Cost Sharing under Coinsurance

The social welfare function

$$W = -(1-q)\exp\left(-\gamma\left(y-p+\varphi\right)\right) - q\left[\alpha\exp\left(-\gamma\left(y-p-p_j+\varphi_j^H\right)\right)+(1-\alpha)\left(y-p-p_j+\varphi_j^L\right)\right]$$

where $j = A, B$

can be rewritten as

$$W = \pi V\left(U(r)\right) + \pi_H V\left(U_H(r)\right) + \pi_L V\left(U_L(r)\right)$$

where

$$\pi = 1-q; \pi_H = q\alpha; \pi_L = q(1-\alpha); U(r) = y-p+\varphi; U_H(r) = y-p-p_j+\varphi_H^j; U_L(r) = y-p+p_j+\varphi_L^j;$$

and $V(.) = -\exp\left(-\gamma(.)\right)$

so that $\dfrac{\partial W}{\partial r} = \pi V'\left(U(r)\right)U'(r) + \pi_H V'\left(U_H(r)\right)U_H{}'(r) + \pi_L V'\left(U_L(r)\right)U_L{}'(r) = 0$

Dividing both sides of the equation by $\dfrac{1}{V'\left(U(r)\right)+V'\left(U_H(r)\right)+V'\left(U_L(r)\right)}$ and solving it for r yields the optimal r as a weighted average

$$r^* = \kappa r + \kappa_H r_H + \kappa_L r_L$$

There is no closed form solution of this welfare maximization problem. However, under the assumption that individuals are extremely risk averse $(\gamma \to +\infty)$, a closed form solution can be obtained. The social planner would then assign all weight to the least-healthy individuals, or in the model, to the L-types. This means that, to determine the optimal r, in the equation above, $\kappa = \kappa_H = 0$ and $\kappa_L = 1$.

Let's calculate optimal r for both cases BB (both types consuming the locally sourced drug) and AB (L-types consuming parallel imported drug and H-types locally sourced drug) under the assumption that $\gamma \to +\infty$.

The Case of BB

When both types consume the locally-sourced drug, social welfare would be

$$W = -(1-q)\exp(-\gamma(y-p+\varphi)) - q\left[\alpha \exp\left(-\gamma\left(y-p-p_B+\varphi_B^H\right)\right) + (1-\alpha)\left(y-p-p_B+\varphi_B^L\right)\right]$$

The optimal r which maximizes social welfare, must then satisfy

$$\frac{\partial W}{\partial r} = (1-q)\left[q\frac{1}{r^2}\left(\varphi_B^L-\varphi_A^L+r\,c_A\right) - q\frac{(1-r)}{r}c_A\right]\kappa + q\left[q\frac{1}{r^2}\left(\varphi_B^L-\varphi_A^L+r\,c_A\right) - q\frac{(1-r)}{r}c_A - c_A\right]\left(\alpha\,\kappa_H + (1-\alpha)\kappa_L\right) = 0$$

Assuming that $\kappa = \kappa_H = 0$ and $\kappa_L = 1$, then optimal r is

$$r^* = \sqrt{\frac{q}{1-q}\frac{\varphi_B^L-\varphi_A^L}{c_A}} > 0$$

If the condition $\varphi_B^L - \varphi_A^L < \dfrac{1-q}{q}c_A$ holds, then the optimal coinsurance rate is $0 < r^* \leq 1$

The Case of AB

When L-types instead consume the parallel imports, social welfare would be

$$W = -(1-q)\exp(-\gamma(y-p+\varphi)) - q\left[\alpha \exp\left(-\gamma\left(y-p-p_B+\varphi_B^H\right)\right) + (1-\alpha)\left(y-p-p_A+\varphi_A^L\right)\right]$$

As above, the optimal r, which maximizes social welfare, must satisfy

$$\frac{\partial W}{\partial r} = (1-q)\left[q\frac{1}{r^2}\left(\alpha\left(\varphi_B^H-\varphi_A^H\right)+r\,c_A\right) - q\frac{(1-r)}{r}c_A\right]\kappa + q\left[q\frac{1}{r^2}\left(\alpha\left(\varphi_B^H-\varphi_A^H\right)+r\,c_A\right) - q\frac{(1-r)}{r}c_A - c_A\right]\left(\alpha\,\kappa_H + (1-\alpha)\kappa_L\right) = 0$$

Assuming that $\kappa = \kappa_H = 0$ and $\kappa_L = 1$, then optimal r is

$$r^* = \sqrt{\alpha \frac{q}{1-q} \frac{\varphi_B^H - \varphi_A^H}{c_A}} > 0$$

If the condition $\varphi_B^H - \varphi_A^H < \frac{1}{\alpha}\frac{1-q}{q} c_A$ holds, then the optimal coinsurance rate is $r^* < 1$.

Appendix B. The Optimal Rate of Cost Sharing under Reference Pricing

The Case of BB

When both types consume the locally-sourced drug, social welfare would be

$$W = -(1-q)\exp(-\gamma(y-p+\varphi)) - q\left[\alpha \exp\left(-\gamma\left(y-p-p_B+\varphi_B^H\right)\right) + (1-\alpha)\exp\left(-\gamma\left(y-p-p_B+\varphi_B^L\right)\right)\right]$$

where $p = q(1-r)c_A$; $p_B = r\,c_A + (c_B - c_A) = \varphi_B^L - \varphi_A^L + r\,c_A$ and $c_B = \varphi_B^L - \varphi_A^L + c_A$.

At the socially optimal r, the welfare function is maximized, so that

$$\frac{\partial W}{\partial r} = \gamma q(1-q)c_A \exp(\gamma q(1-r)c_A)[A - \exp(\gamma r c_A)B] = 0$$

where $A = \exp(-\gamma(y+\varphi))$;and

$$B = \exp\left(\gamma\left(\varphi_B^L + \varphi_A^L\right)\right)\left[\alpha \exp\left(-\gamma\left(y+\varphi_B^H\right)\right) + (1-\alpha)\exp\left(-\gamma\left(y+\varphi_B^L\right)\right)\right]$$

Solving the F.O.C. for r results in

$$r = -\frac{1}{\gamma}\frac{\gamma\left(y+\varphi+\left(\varphi_B^L - \varphi_A^L\right)\right) + \left(\ln\left(\alpha\left(\exp\left(-\gamma\left(y+\varphi_B^H\right)\right)\right) + (1-\alpha)\left(\exp\left(-\gamma\left(y+\varphi_B^L\right)\right)\right)\right)\right)}{c_A}$$

$$r = -\frac{y+\varphi+\left(\varphi_B^L - \varphi_A^L\right)}{c_A} - \frac{\ln C}{\gamma c_A}$$

where $C=\alpha\left(\exp\left(-\gamma\left(y+\varphi_B^H\right)\right)\right)+(1-\alpha)\left(\exp\left(-\gamma\left(y+\varphi_B^L\right)\right)\right)$

It is ambiguous here whether r is larger or smaller than 0 in the optimum.

If one defines a function F of γ and α such that

$$F(\gamma,\alpha)=-\frac{\ln C(\gamma,\alpha)}{\gamma c_A}$$

then $F(\gamma,\alpha)=\begin{cases}\dfrac{y+\varphi_B^L}{c_A} \;\; if \;\; \alpha=0\\ \\ \dfrac{y+\varphi_B^H}{c_A} \;\; if \;\; \alpha=1\end{cases}$

Given that F is an increasing function of α, since $F_\alpha>0$, then for $0<\alpha<1$

$F(\gamma,\alpha)=\dfrac{y+\overline{\varphi}_B}{c_A}$ where $\overline{\varphi}_B\in\left(\varphi_B^L,\varphi_B^H\right)$.

Then,

$$\lim_{\gamma\to\infty}-\frac{\ln C(\gamma,\alpha)}{\gamma c_A}=\frac{y+\overline{\varphi}_B}{c_A}$$

Since, $\varphi>\varphi_B^H>\overline{\varphi}_B>\varphi_B^L$

$$\lim_{\gamma\to\infty} r_{RP}=-\frac{y+\varphi+\left(\varphi_B^L-\varphi_A^L\right)}{c_A}+\frac{y+\overline{\varphi}_B}{c_A}<0$$

Then optimal r^*, again, under the assumption that $\gamma\to+\infty$, is

$$r_{RP}{}^*=-\frac{\varphi+\left(\varphi_B^L-\varphi_A^L\right)-\overline{\varphi}_B}{c_A}$$

The Case of AB

When L-types instead consume the parallel imports, social welfare would be

$$W=-(1-q)\exp\left(-\gamma\left(y-p+\varphi\right)\right)-q\left[\alpha\exp\left(-\gamma\left(y-p-p_B+\varphi_B^H\right)\right)+(1-\alpha)\exp\left(-\gamma\left(y-p-p_A+\varphi_A^L\right)\right)\right]$$

where $p = q(1-r)c_A$; $p_B = r c_A + (c_B - c_A) = \varphi_B^H - \varphi_A^H + r c_A$ and $c_B = \varphi_B^H - \varphi_A^H + c_A$; $p_A = r c_A$

At the socially optimal r, the welfare function is maximized so that

$$\frac{\partial W}{\partial r} = \gamma q(1-q)c_A \exp(\gamma q(1-r)c_A)[(A - \exp(\gamma r c_A)C)] = 0$$

where $A = \exp(-\gamma(y+\varphi))$; and $C = \alpha \exp\left(-\gamma\left(y+\varphi_A^H\right)\right) + (1-\alpha)\exp\left(-\gamma\left(y+\varphi_A^L\right)\right)$

Solving the F.O.C. for r results in

$$r_{RP}{}^* = -\frac{(y+\varphi)}{c_A} - \frac{\ln C}{\gamma c_A}$$

Again, it is ambiguous whether r is larger or smaller than 0 in the optimum.
If one defines a function G of γ and α such that

$$G(\gamma,\alpha) = -\frac{\ln C(\gamma,\alpha)}{\gamma c_A}$$

then $G(\gamma,\alpha) = \begin{cases} \dfrac{y+\varphi_A^L}{c_A} & if \quad \alpha = 0 \\ \\ \dfrac{y+\varphi_A^H}{c_A} & if \quad \alpha = 1 \end{cases}$

Given that G is an increasing function of α since $G_\alpha > 0$, for $0 < \alpha < 1$

$G(\gamma,\alpha) = \dfrac{y+\overline{\varphi}_A}{c_A}$ where $\overline{\varphi}_A \in \left(\varphi_A^L, \varphi_A^H\right)$

Then,

$$\lim_{\gamma\to\infty} -\frac{\ln C(\gamma,\alpha)}{\gamma c_A} = \frac{y+\overline{\varphi}_A}{c_A}$$

Since $\varphi > \varphi_A^H > \overline{\varphi}_A > \varphi_A^L$

$$\lim_{\gamma \to \infty} r_{RP} = -\frac{y+\varphi}{c_A} + \frac{y+\overline{\varphi}_A}{c_A} < 0$$

Then optimal r^*, again under the assumption that $\gamma \to +\infty$, is

$$r_{RP}{}^* = -\frac{\varphi - \overline{\varphi}_A}{c_A}$$

Appendix C. Changes in Welfare from a Change to Reference Pricing

The Case of BB

In the case of BB, total cost – which is the same for both types - is

$$\left[q(1-r_{CI}) + r_{CI}\right]\left(\frac{\varphi_B^L - \varphi_A^L}{r_{CI}} + c_A\right)$$ under coinsurance

and

$q(1-r_{RP})c_A + r_{RP}\, c_A + \left(\varphi_B^L - \varphi_A^L + c_A\right) - c_A$ under reference pricing.

Both types will be better off under reference pricing if

$$\left[q(1-r_{CI}) + r_{CI}\right]\left(\frac{\varphi_B^L - \varphi_A^L}{r_{CI}} + c_A\right) > q(1-r_{RP})c_A + r_{RP}\, c_A + \left(\varphi_B^L - \varphi_A^L + c_A\right) - c_A$$

$$\Rightarrow\ q\left(\frac{1}{r_{CI}} - 1\right)\left(\varphi_B^L - \varphi_A^L\right) + (1-q) r_{CI}\, c_A > (1-q) r_{RP}\, c_A$$

Since $(1-q) r_{RP}\, c_A$ is negative, the inequality will hold if $q < \dfrac{c_A}{\varphi_B^L - \varphi_A^L + c_A}$, so that $0 < r_{CI} < 1$

The Case of AB

In the case of AB, the total cost which H-types face is

$$q\left(1-r_{CI}\right)\left(\alpha \frac{1}{r_{CI}}\left(\varphi_B^H-\varphi_A^H\right)+c_A\right)+r_{CI}\left(\frac{\varphi_B^H-\varphi_A^H}{r_{CI}}+c_A\right) \text{ under coinsurance}$$

and

$$q\left(1-r_{RP}\right)c_A+r_{RP}\,c_A+\left(\varphi_B^H-\varphi_A^H+c_A\right)-c_A \quad \text{under reference pricing}$$

H-types will be better of under reference pricing if

$$q\left(1-r_{CI}\right)\left(\alpha \frac{1}{r_{CI}}\left(\varphi_B^H-\varphi_A^H\right)+c_A\right)+r_{CI}\left(\frac{\varphi_B^H-\varphi_A^H}{r_{CI}}+c_A\right)>q\left(1-r_{RP}\right)c_A+r_{RP}\,c_A+\left(\varphi_B^H-\varphi_A^H+c_A\right)-c_A$$

$$\Rightarrow\; q\alpha\left(\frac{1}{r_{CI}}-1\right)\left(\varphi_B^H-\varphi_A^H\right)+\left(1-q\right)r_{CI}\,c_A>\left(1-q\right)r_{RP}\,c_A$$

Since $\left(1-q\right)r_{RP}\,c_A$ is negative, the inequality will hold if $q<\dfrac{c_A}{\alpha\left(\varphi_B^L-\varphi_A^L\right)+c_A}$, so that $0<r_{CI}<1$

On the other hand, total cost which L-types face is

$$q\left(1-r_{CI}\right)\left(\alpha \frac{1}{r_{CI}}\left(\varphi_B^H-\varphi_A^H\right)+c_A\right)+r_{CI}\,c_A \quad \text{under coinsurance}$$

and

$$q\left(1-r_{RP}\right)c_A+r_{RP}\,c_A \quad \text{under reference pricing}$$

L-types will be better of under reference pricing if

$$q\left(1-r_{CI}\right)\left(\alpha \frac{1}{r_{CI}}\left(\varphi_B^H-\varphi_A^H\right)+c_A\right)+r_{CI}\,c_A>q\left(1-r_{RP}\right)c_A+r_{RP}\,c_A$$

$$\Rightarrow\; q\alpha\left(\frac{1}{r_{CI}}-1\right)\left(\varphi_B^H-\varphi_A^H\right)+\left(1-q\right)r_{CI}\,c_A>\left(1-q\right)r_{RP}\,c_A$$

Again, since $(1-q)r_{RP}\,c_A$ is negative, the inequality will hold if $q<\dfrac{c_A}{\alpha\left(\varphi_B^L-\varphi_A^L\right)+c_A}$ such that $0<r_{CI}<1$.

On the other hand, the change in the welfare of healthy individuals depends on the premiums they pay under the two policies. In the case of BB, they pay

$q\,(1-r_{CI})\left(\dfrac{\varphi_B^L-\varphi_A^L}{r_{CI}}+c_A\right)$ under coinsurance

and

$q\,(1-r_{RP})c_A$ under reference pricing

Healthy people will be better off under reference pricing if they pay less premium than under coinsurance, that is, if

$$q\,(1-r_{CI})\left(\frac{\varphi_B^L-\varphi_A^L}{r_{CI}}+c_A\right)>q\,(1-r_{RP})c_A$$

Under the assumption that $r_{RP}{}^{*}=0$, this inequality implies that

$$\frac{1}{q\,(1-q)}>\frac{\varphi_B^L-\varphi_A^L}{c_A}+4$$

If the probability of getting sick is low, then individuals would pay a lower premium under reference pricing than under coinsurance.

In the case of AB, individuals instead pay

$q\,(1-r_{CI})\left(\alpha\dfrac{\varphi_B^H-\varphi_A^H}{r_{CI}}+c_A\right)$ under coinsurance

and

$q\,(1-r_{RP})c_A$ under reference pricing

Healthy people will be better off under reference pricing if they pay less premium than under coinsurance, that is, if

$$q\,(1-r_{CI})\left(\alpha\frac{\varphi_B^H-\varphi_A^H}{r_{CI}}+c_A\right)>q\,(1-r_{RP})c_A$$

Under the assumption that $r_{RP}^{\ *} = 0$, this inequality implies that

$$\frac{1}{q\,(1-q)} > \alpha \frac{\varphi_B^L - \varphi_A^L}{c_A} + 4$$

If the probability of getting sick is low, then individuals would again pay a lower premium under reference pricing than under coinsurance.

Appendix D. Comparison of Risk Based on Rothschild and Stiglitz's Definition of "Increasing Risk"

Table D1. The income equivalent for H- and L-types when sick or healthy under coinsurance or reference pricing

	Probability	**Income Equivalent**	
		Coinsurance	**Reference Pricing**
Healthy (both types)	$1-q$	$y - p_{CI} + \phi$	$y - p_{RP} + \phi$
H-types Sick	$q\alpha$	$y - p_{CI} - r_{CI}\, c_A + \varphi_A^H$	$y - p_{RP} - r_{RP}\, c_A + \varphi_A^H$
L-types Sick	$q(1-\alpha)$	$y - p_{CI} - r_{CI}\, c_A + \varphi_A^L$	$y - p_{RP} - r_{RP}\, c_A + \varphi_A^L$

Expected income under coinsurance is

$$Ey_{CI} = \underbrace{(1-q)\varphi + q\,\alpha\,\varphi_B^H + q(1-\alpha)\varphi_A^L}_{expected\ health\ stock} - \underbrace{q\,\alpha\left(\varphi_B^H - \varphi_A^H\right) - q\,c_A}_{expected\ total\ cost} \underbrace{- q\,\alpha\left(\frac{1-r_{CI}}{r_{CI}}\right)\left(\varphi_B^H - \varphi_A^H\right)}_{\Delta}$$

and under reference pricing

$$Ey_{RP} = \underbrace{(1-q)\varphi + q\,\alpha\,\varphi_B^H + q(1-\alpha)\varphi_A^L}_{expected\ health\ stock} - \underbrace{q\,\alpha\left(\varphi_B^H - \varphi_A^H\right) - q\,c_A}_{expected\ total\ cost}$$

Ey_{RP} is thus larger than Ey_{CI} by the amount Δ.

If we denote income equivalent under reference pricing by F_{RP}, that under coinsurance by F_{CI}. Let denote the other two discrete variables by $\tilde{G}$ and $\tilde{\tilde{G}}$ where $\tilde{G}$ is constructed by taking Δ from every single individual so that the mean of $\tilde{G}$ is the same as that of F_{CI}, and $\tilde{\tilde{G}}$ is introduced for technical reasons as F_{CI}, F_{RP} and $\tilde{G}$ attribute the same weight to all but six points. However, by definition "if two discrete random variables attribute the same weight to all but four points and if their differences satisfy some conditions we shall say that Y differs from X by a single mean preserving spread".

Table 2 - Discrete Distributions, income equivalent and probability

	Healthy	**Sick**	
		H-type	**L-type**
F_{RP}	I_o' $1-q$	I_H' $q\alpha$	I_L' $q(1-\alpha)$
$\tilde{G}$	$I_o'-\Delta$ $1-q$	$I_H'-\Delta$ $q\alpha$	$I_L'-\Delta$ $q(1-\alpha)$
$\tilde{\tilde{G}}$	I_o $I_o'-\Delta$ δ $1-q-\delta$	I_H $q\alpha$	$I_L'-\Delta$ $q(1-\alpha)$
F_{CI}	I_o $1-q$	I_H $q\alpha$	I_L $q(1-\alpha)$

* Expressions in the upper part of each cell of Table 2 represent income equivalent of utility in different states of being for different types, and terms in the lower part denote probability.

In Table D2 I_i where $i=o,H,L$ represents income equivalent of utility in different states of being, health and sick, for different types, H-types and L-types, explicit forms of which are given in Table D1.

Given that $r_{RP} = 0$, it is straight forward that

(i) $I_o' > I_H' > I_L'$

(ii) $I_o > I_H > I_L$

(iii) $I_o' > I_o > I_o' - \Delta > I_H' > I_H' - \Delta > I_H > I_L' > I_L' - \Delta > I_L$

First we compare the distribution F_{CI} and $\tilde{\tilde{G}}$. They attribute the same weight to all but four points that corresponds to I_L, $I_L' - \Delta$, $I_o' - \Delta$ and I_o. If we denote the difference in weight, the two distributions attached to each point by x_1, x_2, x_3 and x_4 respectively such that

$$x_1 = \Pr(F_{CI} = I_L) - \Pr\left(\tilde{\tilde{G}} = I_L\right)$$

$$x_2 = \Pr\left(F_{CI} = I_L' - \Delta\right) - \Pr\left(\tilde{\tilde{G}} = I_L' - \Delta\right)$$

$$x_3 = \Pr\left(F_{CI} = I_o' - \Delta\right) - \Pr\left(\tilde{\tilde{G}} = I_o' - \Delta\right)$$

$$x_4 = \Pr(F_{CI} = I_o) - \Pr\left(\tilde{\tilde{G}} = I_o\right)$$

Since , following Rotschild and Stiglitz (1970)

(i) $x_1 = q(1-\alpha)$, $x_2 = -q(1-\alpha)$ such that $x_1 = -x_2 \geq 0$

(ii) $x_3 = -1 + q + \delta$, $x_4 = 1 - q - \delta$ such that $x_4 = -x_3 \geq 0$

F_{CI} has more weight in the tail than $\tilde{\tilde{G}}$ does meaning that F_{CI} is riskier than $\tilde{\tilde{G}}$.

Then we compare the two distributions $\tilde{\tilde{G}}$ and $\tilde{G}$. They attribute the same weight to all but four points that corresponds to I_H, $I_H' - \Delta$, $I_o' - \Delta$ and I_o. If we denote the difference in weight, the two distributions attached to each point, by y_1, y_2, y_3 and y_4 respectively such that

$$y_1 = \Pr\left(\tilde{\tilde{G}} = I_H\right) - \Pr\left(\tilde{G} = I_H\right)$$

$$y_2 = \Pr\left(\tilde{\tilde{G}} = I_H{}' - \Delta\right) - \Pr\left(\tilde{G} = I_H{}' - \Delta\right)$$

$$y_3 = \Pr\left(\tilde{\tilde{G}} = I_o{}' - \Delta\right) - \Pr\left(\tilde{G} = I_o{}' - \Delta\right)$$

$$y_4 = \Pr\left(\tilde{\tilde{G}} = I_o\right) - \Pr\left(\tilde{G} = I_o\right)$$

Since , following Rotschild and Stiglitz (1970)

(i) $y_1 = q\alpha$, $x_2 = -q\alpha$ such that $x_1 = -x_2 \geq 0$

(ii) $y_3 = -\delta$, $x_4 = \delta$ such that $x_4 = -x_3 \geq 0$

$\tilde{\tilde{G}}$ has more weight in the tails than $\tilde{G}$ does meaning that $\tilde{\tilde{G}}$ is riskier than $\tilde{G}$. By transitivity, since F_{CI} is riskier than $\tilde{\tilde{G}}$ which is in turn riskier than $\tilde{G}$, then F_{CI} is riskier than $\tilde{G}$.