Income-Based Price Subsidies, Parallel Imports and Markets Access to New Drugs for the Poor*

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Abstract

In health markets, government policies tend to subsidize poorer groups. The purpose of this paper is to analyze the implications of an income-based subsidy policy on the incentives of countries to implement price arbitrage and of firms to provide market access to poorer groups.

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1 Introduction

In health markets, government policies tend to subsidize poorer groups of the society so that they can have access to medicines. Examples of this are the exemptions applied to medicines for children and pensioners in the UK. In the US Medicaid covers poorer sections of society. However, budget pressures mean that there is usually a cost benefit analysis done for each medicine before a government decides whether or not to provide subsidies that would ensure universal coverage. These cost-benefit analyses can be particularly relevant when a multinational company (MNC) develops a new drug and sets a high price for it to cover the innovation costs, which may not be affordable for poorer sections of the society. In India, and other developing countries, essential drugs to fight diseases like tuberculosis, malaria, polio and hepatitis are often distributed fully subsidized to the poor through the public health care systems. But the coverage is extremely low. The investment by the public sector for health in India has been inadequate, so much so that the state has never committed more than 1% of GDP to the health sector in the present decade, compared to 6-7% of GDP accounting for public health expenditure in UK and USA. Added to that is the fact that the private expenditure has risen steadily to around 4 percent of GDP whereas from 1970s there has been a steady decline in public sector investment in India. In China, on the other hand, public health expenditures have been around 1.7% of its GDP, less than 50 percent of what private health expenditures amount to. There is thus a serious concern that the coverage, scope and extent of public expenditure and subsidies should be raised many-fold.

In light of the above mentioned facts, the objective of this paper is to analyze the impact of income based subsidy schemes on drug prices and the extent of market coverage by a pharmaceutical MNC. We also consider the impact that price arbitrage across countries may have over the incentives to implement such policies. An illustration of the potential importance of the above is the pressure being put on the US authorities by the poorer members of society, such as pensioners, to allow for parallel imports from other countries to lower the internal price of medicines.

Ganslandt and Maskus (2007) give a detailed description of the literature on price arbitrage and price discrimination in the context of pharmaceutical markets. As they point out, an under-researched branch of such literature is the design of price regulation and its effects on firm's decisions.[1] A price regulation tool used in the literature is price caps set on the firm's

[1] Ganslandt and Maskus (2007) use a dynamic general equilibrium model to analyze the impact of price controls on the firm's incentives to innovate.

pharmaceutical sales domestically. A good example of this small literature can be found in a recent paper by Grossman and Lai (2006). Jelovac and Bordoy (2005) construct a model of optimal pricing of pharmaceuticals and parallel imports with exogenous quality. The price regulation consists of patients being reimbursed a proportion of the price they pay for medicines, which can be seen as a standard price subsidy. Alternatively, the reimbursement can be interpreted as the co-payment of patients to an insurance company. Still, in their paper, the reimbursement is identical for all consumers although allowed to differ across countries. A more developed insurance system policy can be found in Garber et al. (2006), where in the context of a closed economy the impact of insurance policies on the firm's incentives to innovate has been analyzed.

However, both in Garber et al. (2006) and Jelovac and Bordoy (2005) do not consider income heterogeneity across patients. The heterogeneity comes entirely from the valuation for the pharmaceutical innovation in terms of its efficacy being different for each patient. A problem with this structure, as discussed in García-Alonso and García-Mariñoso (2008), is that the efficacy of medicines varies with each medicine so it is difficult to think of the design of general price regulation policies that would depend on the efficacy of different medicines across patient groups. In our paper, income heterogeneity within a given market is presented as the motive for the design of income related price subsidies.

It is worth noting that in the literature on medical insurance, income is assumed homogeneous and despite that there is some talk of redistribution of income. The idea there is that, if you fall ill there is an income loss as you need to buy medicines and it really against this loss that you are insuring yourself, so the insurance acts as an ex-post redistributive mechanism. So adding ex-ante income heterogeneity would further complicate things. However, in a very simple modeling of insurance, such as the one used in the above quoted papers, this would not be an issue as the insurance is presented as just an ex-post (after you become a consumer/patient) subsidy.

This is exactly what this paper intends to do. We construct a simple model of (intra-country) income heterogeneity and study the implications of price subsidies based on such income heterogeneity on the market coverage by a pharmaceutical MNC. The analytical framework draws heavily from Acharyya and García-Alonso (2006, 2008). In Acharyya and García-Alonso (2006), with no intra-country but only inter-country income heterogeneity, the purpose was to show that under certain restrictions on how the global income was initially distributed across countries, a transfer of income from rich countries (the countries having per capita income level above the world average) to the poor countries would raise the innovation level and thus

make such a transfer essentially self-interested rather than altruistic. The subsequent analysis studies the implications of parallel imports on innovation and price of the drug, and the national welfare levels, when intra-country income heterogeneity exists. In contrast, here we examine whether it is optimal for the national governments to subsidize the poorer groups to ensure their market access when otherwise the MNC would not have catered to them. We make an ex post analysis in the sense that the national governments choose the subsidy levels only after a new drug has been developed by the MNC. The MNC, however, sets the price of the drug and consequently the extent of the market coverage by taking into account the subsidy levels. We also consider the choice of the rich country over allowing parallel imports and subsidizing their poor buyers as alternative means to ensure market access for them.

The interesting but nontrivial results that we derive here in a two-country framework is that when the poor country subsidizes its poor buyers, the rich country may not find it optimal to allow parallel imports of the drug from the poor country. Depending on the level of income of the rich buyers in the rich country, market-based discriminatory prices with unilateral subsidies provided by each country can be part of the Subgame Perfect Nash Equilibrium outcome.

The rest of the paper is organized as follows. In section 2 we set out the model and the time structure. Section 3 analyzes the unilateral subsidy choice of a poor country and the rich country's choice between providing a subsidy and allowing parallel imports of the drug from the poor country, under the assumption of exogenously given quality of the drug. Finally, section 4 concludes the paper.

2 The model

Consider a two-country world. In country i $(i = 1, 2)$, there are two types of individuals, rich and poor with incomes y_{Ri} and y_{Ti} respectively. One can make several alternative assumptions regarding these income levels. We here prefer to assume that whereas the poor have the same income everywhere, $y_{T1} = y_{T2} = y_T$, the richest people live in country 2, $y_{R1} < y_{R2}$. Thus, loosely speaking, we will refer to country 1 as the poor country and country 2 as the rich country.

There is a single pharmaceutical MNC which has a patent over a new drug of quality s that confers it with a monopoly right over its exclusive sales in different markets. Such a monopoly right creates scope for market-based (price) discrimination (MBD) for the MNC. However, its ability to

discriminate may be limited by parallel trading allowed by the countries. The MNC incurs a constant marginal cost of production c.

The government in each country i can set an income based price subsidy (or tax) for the consumption of the pharmaceutical innovation.

Consumers in each country have identical valuations for a particular quality of the drug that is being developed by a pharmaceutical MNC. This valuation is assumed to be linearly related to the income level. Each consumer buys, if at all, only one unit of the drug. Thus a representative consumer of type j in country i derives a (gross) utility from buying a drug of quality s as:

$$u(y_{ji}, s) = y_{ji}s \tag{1}$$

Let n_{ji} be the number of type j consumers in country i.

Let the reservation utility of a buyer of income y_{ji} be zero. Thus, by the individually rational (IR) constraint, she buys the drug if its gross utility is higher than the subsidized price:

$$y_{ji}s \geq \alpha_{ji}P_i \tag{2}$$

where P_i is the price set by the MNC in country i

$$y_{ji}s \geq P_i - \gamma_{ji} \tag{3}$$

where $\alpha_{ji} < 1$ (> 1) and $\gamma_{ji} > 0$ (< 0) would represent a proportional and a specific price subsidy (tax) for income group j in country i respectively.

The general timing for the model we consider is as follows. First the governments in both countries may choose to introduce an income based subsidy. Given such a subsidy choice, the firm chooses the price of the innovated drug and consequently the extent of market coverage. Finally, consumers in both countries choose whether to purchase the innovation or not. We solve the above game using Subgame Perfect Equilibrium concept. As already indicated, consumers in the third stage will purchase the innovation as long as their gross utility is higher than the subsidized price. With this in mind, the MNC will decide whether to set a low enough price that will result in universal coverage in each both or one of the countries or whether to set a (higher) price that will result in some consumer groups not purchasing the innovation. The government foresees the decisions of firms and consumers and decides the optimal income based price subsidy.

The government in each country maximizes national welfare which consists of aggregate consumer surplus minus the cost of the subsidy. In principle no location assignment of MNC is made, and thus the MNC's profit

is not included in the national welfare levels. Thus, say, under full market coverage, welfare of country 1 (assuming specific subsidies) equal:

$$W_1 = n_{R1}\left(y_{R1}s + \gamma_{R1} - P_1\right) + n_{T1}\left(y_T s + \gamma_{T1} - P_1\right) - n_{R1}\gamma_{R1} - n_{T1}\gamma_{T1} \quad (4)$$

which simplifies to

$$W_1 = n_{R1}\left(y_{R1}s - P_1\right) + n_{T1}\left(y_T s - P_1\right) \quad (5)$$

The same expression would hold for proportional subsidies (or taxes). Two comments are warranted. First, in this model with discrete consumer types, subsidies or taxes, lump-sum or proportional, just redistribute incomes across the consumers and the government. The subsidies (or taxes) affect national welfare levels only through their effects on the price of the drug. Second, given the profit-maximizing price choices of the MNC for any given quality of the drug, national welfare, if positive after paying out the subsidies, is higher under full market coverage by the MNC. In that case, even though the poor consumers (with income y_{T1}) find themselves at their reservation utility and thus at the same position as when they are not served at all, the richer consumers benefit from such full market coverage compared to when the poor are not served. Thus, given the objective of maximizing national welfare, the government should subsidize (or tax, as the case may be at the equilibrium) to induce the MNC to serve all income classes, provided of course, the welfare net of subsidies is positive. Thus, as we will elaborate later, under certain restrictions on the cross-country and intra-country income differences, ensuring market access for the poor means maximizing the welfare of the country as a whole even by the narrower measure of welfare in terms of net aggregate surplus in this framework.[2]

3 Choice of Unilateral Subsidy Levels

We start with the case in which price discrimination across countries is possible, i.e., when the countries do not allow parallel trading of the on-patent drug. At the beginning we confine ourselves with specific subsidy, and later will examine whether proportional subsidies make any difference.

[2]The (net) surplus is a narrow measure of welfare in the sense that it attaches no value to an access to the drug per se. If, for example, the drug under consideration is of life-saving importance, the ability to buy the drug itself should be welfare improving compared to when the drug is not affordable, even if the poor get zero net surplus in the sense defined above.

3.1 International price discrimination possible

Consider first the choice of the government in the poor country 1. It is clear from the welfare expression W_1 that, if quality is exogenous, welfare would be maximized by minimizing prices. In this case, if we place no constraint on the value of the subsidy (i.e., we allow for it to be a tax as well), the best the government can do to minimize prices that are charged by the MNC is to lower the purchasing power of the poorer group. Note that for any given subsidy (or tax) to the poorer consumers in country 1, γ_{T1}, to maximize profit the MNC pushes these consumers to their reservation utility if it serves them at all. By the individual rationality constraint (3), the price charged to them for the drug thus equals:

$$y_T s + \gamma_{T1} - P_1 = 0 \Leftrightarrow P_1 = y_T s + \gamma_{T1}. \tag{6}$$

Of course, the MNC will serve the poorer consumers if the following two constraints are satisfied:

First, full coverage is viable:

$$(n_{R1} + n_{T1})(y_T s + \gamma_{T1} - c) \geq 0 \tag{7}$$

and second, it is relatively profitable:

$$(n_{R1} + n_{T1})(y_T s + \gamma_{T1} - c) \geq n_{R1}(y_{R1} s + \gamma_{R1} - c). \tag{8}$$

To ensure (7), the subsidy (or tax) for the poorer group must be

$$\gamma^*_{T1} = c - y_T s \tag{9}$$

whereas to ensure (8), the social planner should ensure that for $\gamma_{T1} = \gamma^*_{T1}$, the subsidy (or tax) for richer people must be equal to γ^*_{R1} :

$$(n_{R1} + n_{T1})(y_T s + \gamma^*_{T1} - c) = (n_{R1})(y_{R1} s + \gamma^*_{R1} - c) \Leftrightarrow \gamma^*_{R1} = c - y_{R1} s. \tag{10}$$

Note that, as long as marginal costs of production are not high, i.e., $c < y_{j1} s$ (which one would expect because otherwise without any subsidy the production of the drug would simply be not viable), the above implies that it would be optimal actually to tax medicine consumption on both groups, with a higher tax for the richer consumer though. The resulting equilibrium price is: $P_1 = y_{T1} s + \gamma^*_{T1} = c$, and therefore, the consumer surplus for each consumer type is zero.

$$\begin{aligned} CS_{R1} &= (y_{R1}s + \gamma^*_{R1} - P_1) = 0, \\ CS_{T1} &= (y_T s + \gamma^*_{T1} - P_1) = 0. \end{aligned}$$

That is, the firm sets the lowest possible price, the consumer surplus is zero for both groups but, that is fine for the social planner because, all that is transferred back to the welfare function in the shape of tax revenue.

The above analysis illustrates the nature of the problem faced by the government. However, since price taxes are not observed, we will constrain subsidies to be non negative. In this case, the best the governments can do is set a zero subsidy on the highest income group and a subsidy on the lowest income group that would ensure full coverage, as this is the only way to put prices down now. Note that the full coverage condition implies that, no subsidy would be given to high income class as that would just increase the incentive for the firm to reduce coverage and therefore, to increase prices. For zero marginal production costs, which will be assumed in rest of our analysis to simplify matters, the relevant condition that defines that subsidy given to the poorer group is

$$(n_{R1} + n_{T1})(y_T s + \gamma_{T1}) \geq n_{R1} y_{R1} s. \tag{11}$$

This immediately yields a subsidy level equal to,

$$\gamma^D_{T1} = \frac{n_{R1} y_{R1} s}{n_{R1} + n_{T1}} - y_T s. \tag{12}$$

This implies that a subsidy to the lower income group should be given (i.e., $\gamma^D_{T1} > 0$) as long as,

$$\frac{n_{T1}}{n_{R1}} < \frac{y_{R1} - y_T}{y_T}. \tag{13}$$

But this is actually the condition that the firm was not going to serve that market without the subsidy, since the number of poorer consumers relative to the number of richer consumers in country 1 (i.e., the relative size of the low-end of the market) is too small in relation to their (relative) income gap.[3]

This will result in an equilibrium price

$$P^D_1 = \frac{n_{R1}}{n_{R1} + n_{T1}} y_{R1} s. \tag{14}$$

[3]This simple setting can be linked to the general idea of price discrimination and subsidies. Felder (2004, 2006) provide an example in a third degree price discrimination setting.

The unilateral optimal subsidy chosen by the rich country can similarly be calculated.

It is now straightforward to check from the following Lemma that giving subsidy is worthwhile:

Lemma 1 *A specific subsidy of γ_{T1}^D paid to the poor in country 1 is welfare improving.*

Proof. Since without subsidy, under condition (13), the MNC serves only the rich buyers in country 1 and leaves them with zero net utility, so it is sufficient to show that $W_1^D > 0$. Substitution of (14) in (5) proves this:

$$W_1^D = n_{T1} y_T s > 0$$

■

3.2 International price discrimination not possible

Now suppose country 2 allows parallel imports which prevent international price discrimination. Though later we will examine the incentive of the rich country to allow such parallel imports, at this point it is sufficient to note that under market based discrimination (MBD), the MNC would charge $P_2^D = y_{R2} s > P_1^D$, so that ensuring a lower price of the drug through international arbitrage is a major source of gain from parallel imports. To focus purely on cross-country income heterogeneity we assume away country-size differences as well as differences in the distribution of the population sizes over the different income classes in each country. That is, we assume $n_{j1} = n_{j2} = n_j$, $j = T, R$.

Suppose only country 1 sets a subsidy γ_{T1} for its poorer consumers. Of course, the subsidy in (15) would be relevant only if without it the MNC does not serve all in country 1:

$$(n_R + n_T)\, y_T < n_R y_{R1}$$

which boils down once again to the relative size of the poor class in country 1:

$$\frac{n_T}{n_R} < \frac{y_{R1} - y_T}{y_T} \tag{15}$$

or alternatively to the following income range for the rich in country 1:

$$y_{R1} > \frac{n_R + n_T}{n_R} y_T \equiv y^* \tag{15a}$$

Of course, in comparing the profits for the MNC under alternative market coverage in (15a), we assume that it is not profitable for the MNC to serve only the rich consumers in the rich country relative to serving rich buyers in both the countries. It is straightforward to check that this would indeed be the case when rich buyers in country 2 are not too rich in the following sense:

$$2y_{R1} > y_{R2} \tag{16}$$

Under parallel imports allowed by country 2, the ability of the MNC to extract surpluses from the rich buyers, when neither country subsidizes its poor, is restricted if it caters to the rich in country 1. If the rich in country 2 are too rich compared to those in country 1, then it is worthwhile for the MNC to forego profit by not catering rich buyers (along with the poor buyers) in country 1 and instead extracting all surpluses from the rich buyers in country 2. However, in rest of the analysis we will confine ourselves with this case that inter-country income difference is not too large to induce the MNC to price out all the buyers, poor as well as rich, in country 1, and thus serve only the country-2 market. This enables a direct comparison of the parallel imports and no-parallel import cases.

From what has been already said, if we constrain ourselves to positive subsidies, the rich group would not get a subsidy as that would only push prices up and reduce welfare according to our definition. Now without similar subsidy provided to the poor in country 2, and with no international transfer of subsidy from country 1, the MNC will cater only to the rich there with income y_{R2}. Thus, for the MNC to cover the full market in country 1, under assumption (16), the subsidy given there should be such that

$$(2n_R + n_T)(y_T s + \gamma_{T1}) \geq 2n_R y_{R1} s. \tag{17}$$

Note that with specific subsidy, the MNC sets the price of the drug in country 1, if he serves all, at $P_1 = y_T s + \gamma_{T1}$. Under parallel import allowed by the rich country 2, the MNC must charge the same price in country 2 as well. But, without subsidy provided to the poor in country 2, the poor consumers in country 2 cannot afford to pay that price, and only the rich consumers there buy the drug. Hence, if the MNC serves all consumers in country 1, it earns a profit equal to what has been specified on the left hand side in (17). The right hand side, on the other hand, specifies the profit when the MNC caters to only the rich consumers in country 1 and charges the price $y_{R1}s$ to extract all the surpluses from them. Under parallel imports, the same price must be charged to the rich in country 2 as well and hence the total profit from partial coverage of both countries equal $2n_R y_{R1} s$.

Under such an assumption, strict equality in (17) gives us the relevant minimum subsidy that will ensure full coverage in country 1 as:

$$\gamma_{T1}^{ND} = \frac{2n_R y_{R1} s}{2n_R + n_T} - y_T s. \tag{18}$$

Hence,

Lemma 2 *The subsidy level required to induce full market coverage in country 1 is greater when country 2 allows parallel imports than that when it does not.*

Proof. Follows from (12a) and (18) that $\gamma_{T1}^{ND} > \gamma_{T1}^{D}$. ■

Given the above subsidy level, the equilibrium price equals,

$$P^{ND} = y_T s + \gamma_{T1}^{ND} = \frac{2n_R y_{R1} s}{2n_R + n_T}, \tag{19}$$

which is higher than P_1^D. To see whether it is still worth giving this subsidy in the first place, all we have to check is whether $W_1^{ND} > 0$. This is because, as already mentioned, without subsidy the aggregate consumer surplus in country 1 is zero since under condition (13), i.e., under partial market coverage, the MNC extracts all surpluses from the rich buyers. Now it is straightforward to check that,

$$\begin{aligned} W_1^{ND} &= n_R \left(y_{R1} s - P^{ND} \right) + n_T \left(y_T s - P^{ND} \right) \\ &= \frac{-n_R n_T y_{R1} + n_T (2n_R + n_T) y_T}{2n_R + n_T} \end{aligned} \tag{20}$$

What follows is that if income of the rich people in country 2 is sufficiently high, country 1 loses from subsidizing its poor to induce the MNC to cater to them. More precisely,

$$W_1^{ND} < 0 \text{ if } y_{R1} > \frac{(2n_R + n_T) y_T}{n_R} \equiv y^{**} \tag{21}$$

This is understandable. Under parallel imports allowed by country 2, the MNC can appropriate higher surpluses from the richer people only by not catering to the poor in country 1. The logic behind giving the subsidy to the poor in country 1 then is to raise their purchasing power and effectively make their size artificially bigger. But the subsidy-inclusive price P^{ND} intended to induce the MNC to serve the poor group in country 1 must be sufficiently high so as to compensate it for the loss of profit from not being able to extract

larger surpluses from the rich buyers in both countries by charging the price $y_{R1}s$. Thus, if the rich people in country 1 are too rich, the government in country 1 has to provide its poor buyers a very high subsidy and in the process compensate the MNC, which significantly raises the (uniform) price, P^{ND}. For the poor a very high price does not matter because they get the subsidy which leaves them with zero (net) surplus. But the rich people in country 1 do not get any subsidy and thus their net surplus declines. In other words, the gain for the rich buyers in country 1 when its government subsidizes its poor, $y_{R1}s - P^{ND} = (y_{R1} - y_T)s - \gamma_{T1}^{ND}$, declines with the level of subsidy. When the required subsidy (and the corresponding price) to induce full market coverage in country 1 is very high, this gain becomes small enough to over-compensate the cost of subsidy and thus country 1 as a whole experiences a welfare loss. Since the required subsidy and consequent (uniform) price rises with the level of rich income. Therefore, it is worthwhile to provide a subsidy to the poor to induce the MNC to serve them as well only when the rich people in country 1 are not too rich in the sense defined in (21) above.

However, even when the subsidy improves the welfare of country 1 (i.e., $y_{R1} < y^{**}$), $P^{ND} > P_1^D$, so it immediately follows that $W_1^{ND} < W_1^D$. Therefore,

Lemma 3 *a) A (specific) subsidy to induce full market coverage in the low-income country 1, when country 2 allows parallel imports, is worthwhile only when $y_{R1} < y^{**}$, where y^{**} is as defined in (21).*

b) Country 1 loses from parallel imports allowed by country 2.

Proof. Follows directly from the above discussion. ■

Note that for a proportional subsidy, the optimal rate would be,

$$\alpha_{T1}^{ND} = \frac{(2n_R + n_T)y_T}{2n_R y_{R1}}$$

which leads to the same (uniform) price $P^{ND} = \dfrac{y_T s}{\alpha_{T1}^{ND}} = \dfrac{2n_R y_{R1} s}{2n_R + n_T}$, as under the specific subsidy. Thus, all the welfare results derived above (and is summarized in Lemma 3) remain the same under a proportional subsidy.

3.2.1 Welfare Property of Parallel Imports and Rich Country's Choice

Lemma 2 above states that country 1 will certainly not prefer parallel imports allowed by country 2. Similar result was shown earlier by Richardson (2002)

and Acharyya and García-Alonso (2008) without any subsidy. We now turn to the incentive for the rich country 2 for allowing parallel imports.

Given the distribution of consumers for which the MNC only partially covers the rich-country market under MBD without any subsidy, namely, $\frac{n_T}{n_R} < \frac{y_{R2} - y_T}{y_T}$, it is trivial to argue that $W_2^D = 0$. But under parallel imports, given that country 1 subsidizes its poor to ensure market access for them for $y_{R1} < y^{**}$, the MNC cannot extract all the surpluses from the richer people in country 2. It is straightforward to check then that given P^{ND} as specified in (19) ,

$$W_2^{ND} = \frac{n_R s((2n_R + n_T)\, y_{R2} - 2n_R y_{R1})}{2n_R + n_T} > 0. \tag{22}$$

So the rich country gains from parallel imports even when country 1 unilaterally imposes a subsidy**.** The reason for this is that the subsidy-inclusive price, P^{ND}, will never be greater than $y_{R1}s$. Otherwise it would not worthwhile to subsidize, and under parallel imports this is the price that the rich buyers in country 2 pay under the assumption in (16).

But, due to this unilateral optimal subsidy by country 1, country 2 cannot get the full benefit of parallel imports since without it giving a subsidy as well, its poorer consumers are still left out by the MNC. The MNC in such a case need not lower the price of the drug in country 2 below what international price arbitrage induces, viz., P^{ND} as specified in (19). Note that for both countries, the source of the welfare gain is lower price charged to their richer buyers. This leads to the question that can the rich country do better by providing a subsidy instead of allowing parallel imports.[4] To check, note that by the similar logic as is spelled out in case of country 1, under MBD the country 2 provides a subsidy equal to,

$$\gamma_{T2}^D = \frac{n_R y_{R2} s}{n_R + n_T} - y_T s$$

resulting in a welfare level equal to,

$$W_2^D(\gamma_{T2}^D) = n_T y_T s \tag{23}$$

Hence, it is readily verifiable that $W_2^D(\gamma_{T2}^D) > W_2^{ND}$ when income of the rich buyers in country 2 is sufficiently small in the following sense:

[4]We here restrict ourselves to parallel imports and subsidy as alternative strategies for the country-2 government. There is, of course, the possibility that the country-2 government opts for both.

$$y_{R2} < y^{***} \equiv \frac{n_T y_T \left(2n_R + n_T\right) + 2n_R n_R y_{R1}}{\left(2n_R + n_T\right) n_R} \tag{24}$$

The intuition is simple. The welfare gain from parallel imports (compared to no parallel imports and no subsidy to poor) comes from the lower price $P^{ND} = \frac{2n_R y_{R1} s}{2n_R + n_T}$ charged to rich buyers compared to all-surplus extracting price $y_{R2}s$ under MBD. Thus, the gain from parallel imports is larger if y_{R2} is sufficiently larger than y_{R1} as implied in (22). But since the gain from providing subsidy to poor buyers in country 2 (compared to MBD) is positive and depends on y_T, so for parallel imports to be more gainful than providing subsidy, the rich people in country 2 must have incomes even larger than what is implied in (22). This is evident from the following decomposition of the value of y^{***}:

$$y^{***} \equiv \frac{2n_R}{(2n_R + n_T)} y_{R1} + \frac{n_T}{n_R} y_T$$

Condition (24) is relevant only if it is compatible with the cross-country income difference we have assumed in (16). It is now straightforward to check that

$$y^{***} < 2y_{R1} \;\forall\; y_{R1} < \frac{(2n_R + n_T) y_T}{n_R} \equiv y^{**}$$

Proposition 4 *In this two country world with two income groups in each country, welfare-maximizing rich country prefers to subsidize its poor instead of allowing parallel imports if* $y_{R2} \in (y^*, y^{***})$ *when* $y_{R1} < y^{**}$*; or if* $y_{R2} \in (y^*, 2y_{R1})$ *when* $y_{R1} > y^{**}$.

Proof. Follows from the above discussion. ■

It is worthwhile to relate this result to Richardson (2002) who demonstrated that in a many-country setting (without any price subsidy) the rich countries will undo price discrimination by allowing parallel imports of a homogeneous drug from the low-income countries. Thus, global uniform pricing was the Nash equilibrium price in Richardson (2002). But, Proposition 1 above establishes that when countries can subsidize their poor to ensure market access, the Richardson result holds only when $y_{R1} > y^{**}$ and $y_{R2} < y^{***}$. Otherwise, MBD (with unilateral subsidies) will be the Nash equilibrium.

4 Conclusions

In health markets, government policies tend to subsidize poorer groups. In this paper, we have analyzed the optimal income-based subsidy policy on the incentives of countries to implement price arbitrage and of firms to provide the poorer groups access to the health care innovation.

What appears from the above analysis is that for a reasonable set of parametric configurations there are incentives for both the countries to provide their poor buyers with price subsidies. It is also to be noted that the optimal subsidy levels depend on the (exogenously given) quality of the drug. These observations warrant attention to two important issues. First, unilateral subsidy choices may be interdependent particularly when markets cannot be segmented on the basis of parametric configurations. Second, the choice of subsidies and innovation level should be interdependent as well when the firm can choose how much to invest in R&D. In fact, once quality of the drug is assumed to be endogenous, interdependence of the national subsidy levels gets stronger since the subsidy level in country i affects that of country j through a change in the innovation choice of the MNC. This constitutes the agenda of our future research.

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