Financing Pharmaceutical Innovation: How Much Should Poor Countries Contribute?*

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Abstract

We use a public economics framework to consider how pharmaceuticals should be priced when at least some of the R&D incentive comes from sales revenues. We employ familiar techniques of public finance to relax some of the restrictions implied in the standard use of Ramsey pricing. In the more general model, poor countries should not necessarily cover even their own marginal costs, and the pricing structure is not related to that which would be chosen by a monopolist in a simple way. We use this framework to examine on-going debates regarding the international patent system as embodied in the WTO's TRIPS agreement.

1 Introduction

It is well recognized that in order to provide private sector incentives for the development of new products and processes, firms must be assured of generating sufficient sales revenue, or given other more direct subsidies such as tax credits. The patent system provides one such mechanism, by allowing a firm to temporarily limit competition and appropriate higher profits. As the penetration of new products into global markets increases, it is arguable that a patent system should provide protection from competition in all markets in which they are sold. One approach would be to institute a global patent. In lieu of this policy, the World Trade Organization has sought to foster the development of consistent national patent systems, in order to implement a decentralized but

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nonetheless coordinated global patent system. Under the TRIPS Agreement,[1] WTO member countries are required to adopt patent laws that comply with certain standards. Firms can then apply for patents in each country separately.

Even if a firm patents an innovation, under WTO rules governments are nonetheless allowed to authorize use of the patented innovation in some circumstances. The purposes are varied: from providing a remedy to prevent anti-competitive behavior on the part of firms, to allowing WTO members "to protect public health and, in particular, to promote access to medicines for all."[2] Compulsory licensing must be accompanied by "adequate compensation" – that is, a license fee paid to the patent-holder. Not surprisingly, legal commentators differ on their interpretation of what constitutes adequate compensation.

The institutional apparatus embodied by TRIPS is one significant factor in determining the prices at which pharmaceutical products (or licenses to produce them) are sold in different countries. More generally, these prices and license payments are the result of negotiations between governments and firms, within a legal and regulatory framework that seeks both to stimulate appropriate levels of R&D, while promoting broad access to available drugs. The public debate over the suitability of the international pharmaceutical prices that emerge from this process has tended to be polarized between those who focus on the incentive effects, and those who concentrate on other social objectives. The purpose of this paper is to provide a framework for determining policy that respects both objectives. To this end, we abstract from most of the legal aspects of the debate, and employ well-established techniques of applied public finance to integrate both efficiency and distributional concerns.

Although our analysis accounts for the need to provide incentives for the development of new products, we do not address formally the important question of exactly how much of an incentive should be provided.[3,4] Further, there is a variety of policy options that could be used to support research and similarly a variety of policies that could be adopted to address distributional concerns. We take the broad composition of these policies as given, and focus our attention on the question of how best to structure pharmaceutical prices. How the analysis presented here fits into the larger choice over efficiency enhancing and distributional policies is discussed briefly in Section 2 below.

[1] Agreement on Trade-Related Aspects of Intellectual Property Rights, Marrakesh Agreement Establishing the World Trade Organization, Annex 1C. Available at http://www.wto.org/english/docs_e/final_e.htm (last visited October 2002).

[2] Paragraph 4 of the Doha Declaration on TRIPS and Public Health. Ministerial Conference, Forth Session, Doha, 9-14 November 2001.

[3] See Nordhaus (1969) and Scherer (1972 and 2003) for a discussion of some of the tradeoffs involved in this decision.

[4] It is often suggested that the R&D investments of the pharmaceutical firm must be "covered" by giving them certain patent rights. However, when R&D is supported by patents, the system determines firms' pricing options *ex ante* (before R&D investment has been made). Firms then *respond* to the system by deciding levels of investment. Given any particular global patent system, firms will choose R&D investment levels with an eye to the future so that whatever is invested can expect to be "covered" by subsequent prices. Thus *ex post* compensation cannot be an argument for any change in patent rules that affect future investments.

Specifically, we consider how the burden of generating any given profit from sales should be shared across countries. To this end, we present basic principles of optimal pricing that are consistent with broadly defined social objectives. These principles have come to be known as Ramsey pricing, after the seminal work of Frank Ramsey (1927).[5]

The techniques we review in this paper are not new. Indeed, some of the literature on pharmaceutical pricing has employed them already (e.g., Danzon, 1997, 2001). Our concern with the bulk of this strand of the literature however is that the assumptions that underlie the derivation of "standard" Ramsey prices are very restrictive. In particular, they require either that concerns about the global distribution of well-being are being fully dealt with through other policies, or that policy-makers have no such concerns. That is, in the absence of alternative policies that can fully satisfy distributional priorities, adopting the standard Ramsey pricing results implies, for example, that the social value of an extra dollar of consumption of an individual in the United States (per capita income $32,000) is the same as the social value of that dollar in India ($460) or Sudan ($320).[6] By allowing for a wider variety of views we hope to be able to identify a fundamental source of disagreement amongst contributors to the policy debate.

Our characterization of social objectives – which is general enough to encompass a broad range of distributional preferences – will be familiar to students and practitioners of applied public economics, although it does not appear to have been explicitly employed in formal analyses of international pharmaceutical pricing. It allows for the fact that (a) the value of additional income might conceivably fall as individuals get richer, and (b) society might have some preference for a more equal distribution of well-being amongst its members. Once one departs from the restrictive assumptions imposed by the "standard" (distributionally neutral) Ramsey pricing model, the pricing rules are replaced by so-called "many-person Ramsey rules" (Diamond, 1975). It becomes clear, then, that Ramsey prices calculated in the standard way are a special case.

In our analysis, we highlight two common prescriptions derived from the standard Ramsey pricing model that are not valid once one allows for a variety of views about social objectives. The first is that prices should at least cover marginal costs in each country – that is, countries should pay at least for the direct costs of delivering drugs. We show on the contrary that this conclusion is only valid when one does not include distributional concerns in the analysis. In general, the notion that countries should cover at least their own costs seems to be grounded in some concept of procedural fairness rather than consideration of consumer welfare.

The second prescription from the standard Ramsey pricing model is that the pricing structure should be closely related to that which would arise if monopoly prices were charged in each country. Again, this feature does not carry over to optimal policies in the presence of distributional objectives.

[5] This work enjoyed a renaisance in the early 1970s, associated with the work of Baumol and Bradford (1970) and Diamond and Mirrlees (1971).

[6] All figures are 2000 GDP per capita in 1995 U.S. dollars (World Bank, 2003).

In addition, we show through an example that the standard model prescribes prices that are higher in countries where the need for drugs is greater. When decision-makers care about equity it would be difficult to rationalize such a policy.

The next section discusses how the problem we examine in this paper fits into the more general problem of the provision of incentives for R&D. Section 3 presents the intuition for and derivation of the many-person Ramsey rule, and relates these rules directly to the determination of reasonable royalty rates on compulsory licenses. In the light of this analysis, Section 4 reviews the more standard Ramsey pricing rules, and illustrates how policy implications drawn from the standard model can diverge from those derived from the more general framework. In Section 5 we illustrate the tradeoffs between pricing, welfare and R&D investment in a simple diagram. With this diagram we are able to explore a number of recent controversies. For example, we examine limitations on firms' abilities to set differential (or "tiered") prices in the face of arbitrage or reference pricing by regulators; and the introduction of patents on drug products in the developing world as a requirement of WTO membership. Section 6 concludes.

2 Financing R&D incentives

The formulation of pharmaceutical pricing policy can be usefully thought of as proceeding in three steps. First, the total size of the resources that society should devote to research needs to be established and how this relates to the investments made in the absence of policy support; second, the broad mechanisms by which the desired research investment can be obtained need to be identified; and thirdly, the best design of each broad mechanism must be determined. Although the focus of our paper is on this third step, for clarity we briefly discuss each step in this section.

2.1 How big an incentive should be provided for innovation

The first step in the policy-making process is to identify the extent to which the level of innovation is below what it should be. In general, the "right" level of R&D will depend upon the extent to which research investment leads to the discovery of new products, an evaluation of the benefit of new products vs. other goods that could otherwise have been obtained, rates of time preference (since research pays off in the longer run), and the cost of stimulating different levels of innovation. These benefit and cost factors could be used to determine the financial return that firms would need to be guaranteed in order to be willing to engage in the "right" level of R&D.[7]

[7] To illustrate with a practical example, the length of a patent determines (in part) the value of monopoly profits that a firm can expect to generate from new innovations. Choosing a longer life is one way of increasing support for research.

2.2 How to support innovation

A variety of mechanisms exist for providing R&D incentives. The patent system promises future profits on sales. Various tax credits and subsidies (e.g., the orphan drug legislation in the U.S.) provide returns not so much for *successful* innovation, but simply for *attempts* at innovation (i.e., at the research stage). Alternatively, some R&D is funded directly by the government, through public sector institutions (such as the National Institutes of Health in the U.S.). For our purposes it is useful to distinguish simply between research support that is derived from profits on sales of successful innovations, call this $\$R$, and that which is provided through the general tax system.

If the provision of R&D incentives was simply a funding exercise, then the appropriate way to finance incentives would be that which led to the collection of resources in the most efficient and equitable fashion. A powerful result of Atkinson and Stiglitz (1976) establishes that under certain conditions, if a government wishes to raise a given amount of revenue with both efficiency and equity objectives in mind, it should do so by implementing a suitably designed income tax and abstain from taxing the consumption of goods and services separately.[8] In the context of pharmaceutical pricing, this would mean that prices should be set equal to marginal cost, and R would be zero.

However, we suggest that in practice there are sound reasons why sales revenues in excess of marginal costs might represent a useful source of financing. First, the form in which research support is provided can affect the productivity of the investment. In particular, when support comes from sales of products, it gives researchers a strong incentive to direct their efforts to finding products that address consumer needs rather than, say, working on projects that are primarily of scientific interest. Second, it might be easier for governments to commit to allowing a successful firm to charge certain prices than to follow through on a promise to hand over a large sum of tax revenue. And finally, it might be easier to maintain political support for the overall R&D incentive if at least some of the funding does not come from explicit tax increases.[9]

It might be possible to argue that equity concerns should still be addressed through a global tax system as suggested by the Atkinson-Stiglitz result with an adjustment to allow for the fact that some revenue is to be raised from sales. For example, we might infer that pharmaceutical prices should be set in a distributionally neutral fashion, because the income tax system should be the vehicle for addressing distributional concerns. We agree with this contention in principle, but note that the Atkinson-Stiglitz result requires the availability of a sophisticated (non-linear) world-wide income tax. Clearly we are far from having the global institutions in place to implement this approach directly and there are good reasons that a global income tax is not in place, including

[8] This result is in the context of a static model, in which there are no savings. In an inter-temporal model with savings, the result in fact indicates the optimality of a (non-linear) consumption tax over an income tax under which the returns to savings would be taxed. See Atkinson and Stiglitz, 1980.

[9] Of course, we are not suggesting that prices above marginal cost are not taxes, but they are perceived differently by voters.

institutional and political constraints, and corruption.

If one views current institutions as inadequate to directly address distributional issues at a global level there are two implications for policy. First, if equity concerns cannot be addressed directly then it becomes important to take into account the distributional implications of all policies, including policies that determine drug prices. Second, if it is considered desirable to redistribute and direct approaches are not available to attain this outcome, then other policy options must be explored. Drug pricing may well be one of the more effective tools available since it targets a basic human need and provides resources in a form more difficult to divert than, say, direct transfers to country governments.

2.3 Pricing to yield R

Having established the size of the research support that society is willing to provide, and the division of this incentive between taxes and sales revenues above marginal costs, the last issue to address is the design of the price structure that will yield the required revenue, R. This is the primary subject of our paper. In this sub-section we simply note two points. First, our results will apply to *any* level of R: as the choices made in steps 1 and 2 change, our pricing formulae will remain unaffected (although the actual prices prescribed will of course change). That is, our general insights into the structure of prices conditional on R remain informative as R changes.

Second, the design of the price structure, and possible practical limitations on it, will inform and feed back into the decisions made in steps 1 and 2. For example, if certain constraints mean that the feasible prices are much different from those that would otherwise be considered optimal, for a given R, then we might want to shift more of the financing into taxes and pursue other avenues for attaining distributional goals. Further, we may revise our evaulation of the total resources that should be devoted to research in light of the fact that otherwise desirable pricing policies are unavailable.

With this in mind, the reader should perhaps interpret our findings as the first input (working backwards) in the solution to the overall three-step problem of finding ways of inducing R&D in a world in which policy-makers care about dynamic efficiency (i.e., R&D incentives), static efficiency (e.g., the distortionary costs of monopoly pricing), and equity.

3 Ramsey pricing

We start by considering the simplest model with two countries, north and south. The same analysis would hold for any number of countries. We also assume both countries have the same number of residents, and that residents are identical within each country. Thus for simplicity we can assume that each country $i = n, s$ has a single consumer.[10] This person chooses between two goods, x

[10] It can be shown that the optimal pricing rules are the same for any distribution of population across countries, although the level of prices would differ.

(which represents all other goods and whose price is normalized to one), and a drug, y. The drug is available in country i at a price p_i, and income of the individual there is m_i.[11] Incomes can vary across countries. Individual i's preferences over consumption of the two goods are represented by a function $u_i(x, y)$. To start with we will assume that both individuals have the same preferences regarding the two goods. However, later in the next section we shall allow preferences for drugs to differ in north and south, say due to differences in disease conditions and health needs.

Given these preferences, we can determine the highest level of "utility" the individual can attain when his income is m_i and the drug price is p_i (it is standard and convenient to refer to individual welfare as utility to distinguish it from the aggregate well-being of all individuals, social welfare). As there is no saving in this simple model, individuals will spend their entire incomes and $x + p_i y = m_i$. Then individual i's maximal utility level (his indirect utility function) for any price and income can be written

$$\begin{aligned} v_i(p_i, m_i) &= \max_{x,y} u_i(x, y) \\ &\quad \text{s.t.} \quad x + p_i y = m_i. \end{aligned}$$

To formalize the policy objective, we assume drug prices are chosen to make some concept of global aggregate well-being as large as possible. Following a long tradition of applied public economics, we describe this goal in terms of social welfare, which depends on the utility attained by individuals in both countries. That is, social welfare is a function $W(v_n, v_s)$. How much a small increase in the utility of individual i contributes to social welfare depends on how W is defined. It can also depend on person i's starting level of utility, as well as the utility levels of other individuals. We will denote the incremental effect of an increase in person i's utility by $\gamma_i = \partial W / \partial v_i$.

To determine appropriate prices across countries, it is useful to observe that the way in which a price increase in country i affects social welfare can be decomposed into two pieces. First, increasing the drug price for individual i will generally lower his utility (unless he was not consuming the drug in the first place.). If his drug consumption was y_i initially, and remains at that level after a small *increase* in the drug price Δp_i, the effect of the price increase will be the same as if he had experienced a *reduction* in his income of $\Delta m_i = \Delta p_i y_i$. We will thus be better able to assess the first impact of a price increase in country i if we know what effect a reduction in income there would have on individual utility. This *marginal utility of income*, is typically denoted by $\alpha_i = \partial v_i / \partial m_i$. Studies of behavior under conditions of uncertainty indicate that α_i is very likely to decline as an individual's level of income increases. That is, a person gets less benefit from an extra dollar as he becomes richer.[12]

[11] m_i is income net of any contributions t_i to tax-financed R&D incentives, T. For our purposes, taking the t_i as given, it is the distribution of m_i across countries that matters, not the distribution of t_i. Since the t_i are small relative to the m_i, this distinction is of little practical importance.

[12] Note that the value of α only indicates how a given individual would view an extra dollar

Second, as discussed above, the reduction in consumer utility in country i (Δv_i) will have an effect on social welfare. The two pieces together give the total effect on social welfare of a change in income in country i. This is the key component of the analysis. Following the standard literature (e.g., Atkinson and Stiglitz, 1980), we denote this as β_i,

$$\begin{aligned} \beta_i &= \frac{\partial W}{\partial v_i}\frac{\partial v_i}{\partial m_i} \\ &= \gamma_i \alpha_i. \end{aligned}$$

Using the relationship between price and income changes, $\Delta m_i = \Delta p_i y_i$, noted above, changing the drug price in country i would have the following effect on social welfare:

$$\begin{aligned} \frac{\partial W}{\partial p_i} &= \frac{\partial W}{\partial v_i}\frac{\partial v_i}{\partial p_i} \\ &= -\beta_i y_i. \end{aligned} \tag{1}$$

Thus lowering the price of the drug in country i tends to be most beneficial when β_i is large. The value of β_i is large when extra income is particularly valuable to the person in country i (large α_i) and when boosting the well-being of those in i is viewed as particularly important (large γ_i). For example, if extra income is more valuable to people who are poor, then letting the south be the poorer country, this means $\alpha_s > \alpha_n$. Second, a preference for a more equal distribution of well-being rather than a less equal distribution would imply that $\gamma_s > \gamma_n$.[13] Thus on both accounts one might expect to have $\beta_s > \beta_n$. One objective of this paper is to bring attention to the fact that the use of public economics in the policy debate regarding international drug pricing has implicitly assumed a very special, and we would argue unrepresentative, case: one in which both α_i and γ_i, and hence β_i, are constant across all countries at all incomes.

3.1 Derivation of Ramsey prices

In this sub-section we use the model described above to characterize the optimal drug price in each country. We assume that the marginal cost of producing and distributing the drug is constant within a country, but can vary across countries,

if he were poor as compared to if the *same* individual were rich. A declining value of α does not necessarily imply that an extra dollar would give every rich person less utility than it would give to any poor person. We can only make that assertion if individuals derive the same utility from consumption, as is assumed in this section.

[13] Usually we adopt the assumption that the welfare function is *anonymous*, in that it does not discriminate between individuals directly. However, it is possible that decision makers might adopt a welfare function that does not have this feature. If one cared less about the well-being of individuals from the south, for example, then, all else equal, this would tend to lower γ_s relative to γ_n. A sufficiently strong preference for one group over the other could imply a desire to redistribute from the poor south to the richer north.

and is equal to c_i in country i.[14] Now, suppose that for a given product the innovator firm is permitted to generate sales revenue over costs of R. The optimal set of drug prices p_n and p_s are those that give the highest social welfare, W, subject to this revenue constraint. We assume here that profits (or losses) on sales accrue to the firm. This means either that the firm sells the drug directly; or that it controls and sets the terms of licenses to alternative manufactures; or, if licensing is compulsory, that there is sufficient competition amongst generics manufacturers that they do not profit from sales themselves. It also means that there are no import or sales taxes.[15] Formally, these prices solve the problem

$$\begin{aligned} \max_{p_n, p_s} \quad & W(v_n, v_s) \\ \text{s.t.} \quad & \sum_i (p_i - c_i) y_i = R. \end{aligned} \tag{2}$$

We introduce a Lagrange multiplier, λ, on the constraint, so that the first order conditions satisfied at the optimal prices are

$$\frac{\partial W}{\partial v_i}\frac{\partial v_i}{\partial p_i} + \lambda \left(y_i + (p_i - c_i)\frac{\partial y_i}{\partial p_i} \right) = 0 \quad ...i = n, s. \tag{3}$$

This condition has the following intuition. The (negative of the) first term is the *marginal social cost* (i.e., the incremental reduction in social welfare) associated with a price increase in country i; denote this by MSC_i. The bracketed part of the second term is the *marginal revenue* earned from a price increase in country i; call this MR_i. The condition then says that for each country

$$\frac{MSC_i}{MR_i} = \lambda. \tag{4}$$

The ratio on the left hand side is the reduction in welfare as revenue generated by sales in country i increases. Since λ is the same for both countries, this means that the marginal social cost of revenue generation is equalized across countries. That is, at the optimum prices, raising an extra dollar from either country should have the same (negative) effect on social welfare: if the marginal welfare loss per unit of net revenue differed between countries, then the amount earned from each could be adjusted, keeping aggregate net revenue constant at R, while reducing the total social cost.

Using expression (1), equation (3) can be rearranged as

$$\frac{(p_i^* - c_i)}{p_i^*} = \left[\frac{\lambda - \beta_i}{\lambda} \right] \frac{1}{\eta_i} \tag{5}$$

[14] The marginal cost of delivery could vary within a country where access to rural and remote areas is difficult. We abstract from this problem here. We also assume that the costs associated with launching a product in an additional country (obtaining marketing approval, advertising to doctors, arranging distribution, etc.) are negligible.

[15] That is, we assume the innovating firm receives all revenues generated by consumer purchases in excess of marginal cost, and that none accrue to governments, through taxes.

where p_i^* is the optimal ("Ramsey") price in country i, and $\eta_i = -\frac{p_i}{y_i}\frac{\partial y_i}{\partial p_i} > 0$ is the elasticity of demand for the drug in that country.[16] It measures how sensitively people react by adjusting their consumption of drugs when prices change. The Lagrange multiplier, λ, measures the social value of relaxing the financing constraint by a dollar - that is, the gain in social welfare that would accrue if the revenue allowed the firm, R, was marginally reduced. As discussed above, β_i measures the increase in social welfare associated with an increase in the income of the individual in country i by a dollar.

For a given elasticity of demand, the mark-up as a share of final price is smaller the larger is β_i. As argued above, one might expect β_i to be larger in a poor country, which would suggest lower mark-ups there. In fact, in general there is no reason to expect that, at the optimum prices, $\beta_i < \lambda$ for all countries i (although it must be the case that $\lambda > \beta_i$ for at least one country for revenue to be non-negative). That is, the term in square brackets could even be negative. This means that *Ramsey prices do not necessarily cover marginal costs in all countries*, since if the right hand side of (5) is negative, $p_i^* < c_i$ This possibility is illustrated graphically in the appendix. (Whether such prices can be attained given available policy tools is considered in section 5.1).

Finally, note that the condition refers to the mark-up over cost as a share of price. If the marginal cost of producing and distributing the drug, c_i, is the same across countries then a lower mark-up in country i also implies a lower price in country i. If it is not the same, then the final price, p_i, could be higher in the country with the lower mark-up.

3.2 Ramsey Reasonable Royalty Rates

The TRIPS agreement allows for the compulsory licensing of patented innovations in some circumstances. These licenses give manufacturers the right to produce and sell a patented product in the country issuing the license in return for adequate remuneration to the patent holder (TRIPS, art. 31h and 31k). In general when compensation is due a patentee it is commonly in the form of royalty payments per unit of sales, and laws requiring compensation are sometimes directly specified in relation to reasonable royalties.[17] What "reasonable" might be is not clearly stated and is open to interpretation.[18] One natural way to approach this problem in the international context would be to follow the same line of reasoning used here and to ask what royalty rates would generate the highest level of social welfare.

Royalty payments are typically defined as a share of the final sale price. Thus, if the royalty rate to be paid to the inventor on sales in country i is,

[16] Throughout this paper, we assume that optimal prices - including both Ramsey prices and monopoly prices - are unique.

[17] In assessing damages in infringement cases, for example, 35 U.S.C. § 284 provides that damages should be "...in no event less than a reasonable royalty for the use made of the invention...".

[18] See Scherer and Watal (2002) for an interesting discussion of historical practice within countries.

say, r_i then the marginal cost of production to the manufacturing firm becomes $c_i + r_i p_i$. If the market is competitive - that is there are several generics producers operating under compulsory license - then price will equal the marginal cost of production: $p_i = c_i + r_i p_i$. In this case,

$$r_i = \frac{p_i - c_i}{p_i} \tag{6}$$

and the royalty rate in country i will determine the mark-up as a share of price in that country.[19] Thus, given competition, it follows directly that the "Ramsey reasonable royalty rate" is defined by condition (5). Note that this royalty rate depends on demand characteristics (e.g., demand elasticities, η_i) as well as social marginal utilities of income, the β_i. It does not depend on concepts such as the "damage" suffered by the innovator firm.

4 Standard Ramsey prices

In this sub-section we present the special case of the model illustrated above that has been used in the discussion of international drug prices. We highlight two common prescriptions derived from this special model, and show how they are at odds with those drawn from the more general formulation above. The first is that prices should at least cover marginal costs in each country. The second is that the pricing structure should be closely related to that which would arise if monopoly prices were charged in each country. We also show that the special model would suggest that prices should be higher in countries where the need for drugs is greater. This inference is not typically noted.

4.1 Consumer surplus, Ramsey prices, and "fair" prices

The standard approach does not incorporate any concern for the distributional effect of drug prices. There are two interpretations of this treatment. First it could be taken to mean that distribution simply does not matter. This requires assuming that an extra dollar gives the same amount of additional utility to an individual, irrespective of his starting income level. That is, the marginal utility of income, α_i, is constant. Further, it requires that the way in which any total amount of utility is distributed between the two individuals is not given any particular importance. Formally, a social welfare function is *implicitly* assumed and it is utilitarian:

$$W(v_n, v_s) = v_n + v_s.$$

With the utilitarian social welfare function, $\gamma_s = \gamma_n = 1$. Together with the constant marginal utility of income, this means that $\beta_i = \beta$ is also constant.

[19] Without competition and absent price controls the price would be higher. Some of the resulting revenue would go to the inventor as royalty payments and some would go to the generics producer as profit.

The second interpretation is that distribution does matter, but that it is expected to be dealt with in other ways. If one believes that there are other (unused but nevertheless effective) avenues for bringing all individuals in the world to a similar level of well-being, then clearly distributional concerns can be safely ignored when thinking about drug pricing. In either interpretation, β_i can be treated as constant across countries, and the optimal pricing conditions (5) simplify to

$$\frac{(\widehat{p}_i - c_i)}{\widehat{p}_i} = \left[\frac{\lambda - \beta}{\lambda}\right] \frac{1}{\eta_i}, \tag{7}$$

where $\widehat{p}_i$ is the optimal price, and $\beta = \alpha\gamma = \alpha$.[20]

The term in square brackets, $[(\lambda - \beta)/\lambda]$, is now constant across countries.[21] Thus we have the standard result that prices should differ across countries in such a way that the proportional mark-up as a share of price is inversely related to the elasticity of demand at those prices. This rule implies higher prices for those who will change their consumption less, and it is efficient because it causes the least distortion to consumption patterns.

The rule has been interpreted more loosely as requiring that prices be higher in countries with lower demand elasticities. We say "more loosely" because the elasticity of demand is typically not constant as a function of price. Indeed, in the case when marginal costs are zero, condition (7) collapses to $\eta_i = [(\lambda - \beta)/\lambda]$: that is, prices should be set so that the elasticity of demand is equal across countries. In general this will require differential prices if the relationship between price and elasticity differs by country.

Finally, it can be argued in this special case that at the optimal prices, $\lambda > \beta$, so that the price in each country is at least as high as c_i, the marginal cost of

[20] It is common in the literature on regulation and utility pricing, and in some accounts of international drug pricing, to adopt the maximization of a measure of aggregate consumer surplus as the policy objective. This approach can be reconciled with the one we adopt here. First observe that a small price change dp_i has an effect on individual i's utility given by

$$\frac{\partial v_i}{\partial p_i} dp_i = -\alpha_i [y_i dp_i]. \tag{8}$$

Consider lowering the drug price from a very high level in country i. As the price falls from ∞ (at which demand is zero) to p_i (at which demand is positive) we need to account for the fact that demand changes as its price changes. If α_i were to remain constant as the price changed, then the utility change associated with the change in prices would be the sum of the incremental changes. That is, using (8)

$$\begin{aligned} v_i(p_i, m_i) - v_i(\infty, m_i) &= \alpha_i \int_{p_i}^{\infty} y_i(p_i') dp_i' \\ &= \alpha_i CS_i(p_i) \end{aligned} \tag{9}$$

where $CS_i(p_i) = \int_{p_i}^{\infty} y_i(p_i') dp_i'$ is the change in consumer surplus of individual i as the price changes from ∞ to p_i.

With $\alpha_i = \alpha$ for $i = n$ and s, and a utilitarian social welfare function, we then have

$$W = \alpha[CS_s(p_s) + CS_n(p_n)],$$

which is aggregate consumer surplus.

[21] This term is sometimes written as $\frac{\mu}{1+\mu}$ where $\mu = (\lambda - \beta)/\beta$.

production and distribution there. We do this graphically in the appendix.

It is tempting to interpret the condition that each country cover at least its own marginal costs as "fair". But this can only be in a procedural sense. Our analysis demonstrates that putting such a condition on prices only emerges as a general policy prescription when concern for equity is ruled out. If alternative views about distribution are allowed then it no longer holds as a general principle.

4.2 Comparison with monopoly pricing

If a single firm were producing and selling the drug, and if the firm could freely choose prices in separate country markets, it would set prices so as to maximize net revenue, $R = \sum_i (p_i - c_i) y_i$. The first order condition for this problem is simply

$$\left(y_i + (p_i - c_i) \frac{\partial y_i}{\partial p_i} \right) = 0 \tag{10}$$

which is the same as condition (3), except that it does not have a term giving weight to social welfare. The monopolist would thus choose prices p_i^m in different countries to satisfy

$$\frac{(p_i^m - c_i)}{p_i^m} = \frac{1}{\eta_i}.$$

Comparing this condition with (7) we see that the relative price-cost mark-ups derived in the special case above are proportional to those that would be chosen by a price-discriminating monopolist. That is, if $\mu_i = (p_i - c_i)/p_i$ is the mark-up as a share of price in country i, then

$$\frac{\mu_s^m}{\mu_n^m} = \frac{\eta_n}{\eta_s} = \frac{\widehat{\mu}_s}{\widehat{\mu}_n}.$$

These can be compared to the ratio of price-cost mark-ups under the optimal Ramsey prices characterized in (5):

$$\frac{\mu_s^*}{\mu_n^*} = \left(\frac{\lambda - \beta_s}{\lambda - \beta_n} \right) \frac{\mu_s^m}{\mu_n^m}.$$

If $\beta_s > \beta_n$, then the relative mark-up in country s is smaller than the relative mark-up that would be chosen by a price-discriminating monopolist.

4.3 Heterogeneous health needs

The disease burden differs markedly across countries, so some pharmaceutical products will be in higher demand in some countries than others. Demand for pharmaceuticals may also be higher in some countries because alternative medical treatments are more costly or unavailable. Perhaps the easiest way to

incorporate these country differences into the Ramsey pricing analysis is to suppose that the utility that individuals in country i obtain from the consumption of drugs, y, and other products, x, can be written

$$u_i(x, y) = \phi\left[x + \theta_i \upsilon(y)\right],$$

where θ_i measures the value of drugs relative to other consumption in country i.[22] Given this utility function, at any price p_i, individuals in country i have a demand for drugs $y_i(p_i; \theta_i)$ that satisfies the condition

$$\theta_i \upsilon'(y_i) = p_i.$$

This condition implies that demand for the drug depends on its price and the person's needs, θ_i, but not on the person's income.[23] The elasticity of demand is then

$$\eta_i(y_i; \theta_i) = -\frac{1}{\theta_i} \frac{\upsilon'(y_i)}{y_i \upsilon''(y_i)}.$$

In the special case where $\upsilon(.)$ induces constant demand elasticity, $-y\upsilon''/\upsilon' = \rho$,[24]

$$\eta_i = \frac{1}{\rho \theta_i}.$$

Countries with greater need for drugs (higher θ_i) have lower demand elasticities.

The Ramsey pricing rule (5) now becomes

$$\frac{(p_i - c_i)}{p_i} = \rho \left[\frac{\lambda - \beta_i}{\lambda}\right] \theta_i. \tag{11}$$

This means that the mark-up is greater, the greater are health needs (as measured by θ_i) and the smaller is β_i. In the special case of a utilitarian social welfare function and constant marginal utility of income ($\phi' = 1$), so that $\beta_i = \beta$ for all i, only the first effect is relevant, and (11) prescribes that countries with greater needs should face higher prices. In our mind, this result again highlights the inadequacy of distributionally insensitive pricing rules, as it is likely that countries with greater needs for pharmaceuticals will also be relatively poorer.

5 Policy Illustrations

The Ramsey prices described in the preceding sections are optimal prices: that is, they give the highest level of social welfare while allowing the firm a certain

[22] These preferences are called quasi-linear. $\upsilon(.)$ is increasing and concave and $\phi[.]$ is increasing and weakly concave.

[23] This is clearly an extreme assumption, and isolates only one determinant of demand for drugs. In general we would expect, at least for some diseases, demand for drugs, and the elasticity of demand, to depend on income.

[24] Such a $\upsilon(.)$ takes the form

$$\upsilon(y) = \frac{y^{1-\rho}}{(1-\rho)},$$

where $\rho \in (-\infty, 1)$.

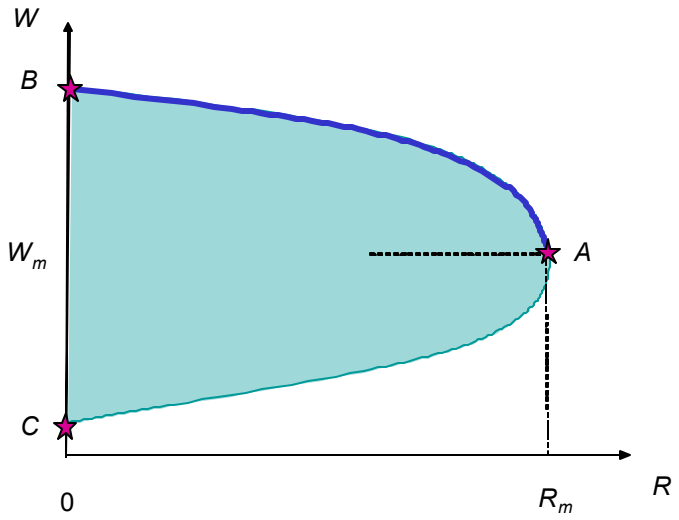

Figure 1: All points in the shaded region, representing revenue-welfare pairs (R, W), are attainable. Those on the upper boundary are attained by setting Ramsey prices.

revenue in excess of marginal production costs. But how do these prices compare with those we might expect under various regulatory and patent regimes? This section presents a graphical tool that allows us to conveniently compare alternative policy choices, both to each other, and to the benchmark Ramsey prices. In the discussion of this section we relax the assumption that there are only two countries.

As noted in the introduction, the strength of the incentive given to firms to engage in R&D - that is, the net sales revenue of a given pharmaceutical product - is itself a policy choice. In many cases, a given net revenue target R can be reached with a variety of international price structures. Some of these might result in much of the revenue R being raised in richer countries, while others might result in it being primarily raised in poorer countries. For any given revenue target, different pricing policies for a given drug result in different levels of social welfare. The shaded area in Figure 1 depicts all of the combinations of net revenue and welfare, (R,W) that can be obtained with different sets of global drug prices.

To understand the construction of Figure 1 begin with point A. At this point, the revenue allowed to the firm, R_m, is the amount that would be raised by a profit maximizing monopolist able to separate markets. This particular net revenue target can *only* be reached if the price in each country is the monopoly price for that country, p_i^m. When monopoly prices are charged in each country social welfare is W_m. By definition, there are no prices that yield revenue greater than R_m.

Now let us consider another extreme - the case in which the firm receives no revenue in excess of marginal costs, that is, $R = 0$. There is a set of Ramsey prices associated with this revenue target and these prices yield the highest level of social welfare, shown as point B in the figure. Moving to the right from this point, because the revenue target increases prices in one or more countries have to increase. Thus the highest attainable welfare falls until we reach point A with welfare W_m. These maximum welfare levels, reached when Ramsey pricing is used to generate any given net revenue target, are depicted by the bold line in Figure 1.[25]

Just as there is a maximum level of welfare than can be reached for a given revenue target, there is also a minimum. The simple intuition behind this observation is that for any country, as the price of a pharmaceutical increases, revenue first increases (as the higher price is not fully offset by falling demand) but then falls (as higher prices cause demand to decrease enough). Thus a certain revenue can be generated in a particular country in two ways - by either a low or a high price. There will be some set of relatively high prices that yield the lowest possible social welfare for any net revenue target. These "worst possible" welfare and revenue combinations form the bottom edge of the shaded area in Figure 1.

For any given R, points between the upper and lower boundaries represent welfare levels between these extremes. Assuming continuity, there are prices that can generate any of these intermediate levels of welfare, all allowing the firm exactly R. As this is true for any R, all of the combinations of R and W in the shaded area can be attained by setting different drug prices.

Finally, we note that the points in the shaded region can be reached only if net sales revenue, R, in combination with other subsidies, T, are together sufficiently high to elicit the research investment, V, required to invent the product. That is, $R + T \geq V$. However, the single point C has a dual interpretation. Point C, like all of the other points, represents a level of net sales revenue and of welfare that can be obtained for a given drug should it be discovered and developed. At this point the drug is priced so high that demand is zero in all countries, and consequently welfare is very low. Because no one is consuming the drug at point C, this point also represents the sales revenue (zero) and welfare that would obtain in the absence of the drug. It is where we start before the drug is brought to market, and where we remain if the drug fails to be discovered.

5.1 Limitations on implementable prices: voluntary participation

In our discussion of Ramsey pricing thus far we have assumed that it is possible to set any price in any country. If all pharmaceuticals were sold by governments then they could agree to charge consumers any set of prices. However,

[25] If no value is put on the well-being of some individuals then their prices can be raised first without affecting the level of social welfare. In this case the bold line would be horizonal at low revenue levels.

in many countries pharmaceutical marketing is done primarily by the private sector. Policy-makers often control prices only indirectly and their options may be limited by the available policy tools and by the ways in which prices in one country affect those elsewhere. In this and the following sub-sections we consider what prices could be implemented in practice.

If firms can separate markets then the country-specific monopoly price can be reached in each country by granting firms strong and well-enforced patent rights - in particular, rights that are not compromised by compulsory licensing. Prices below the monopoly level can be attained by granting firms patent rights and then regulating price levels. Most developed countries follow this strategy and price controls come in a wide variety of forms.

Arriving at price equal to marginal cost can, in principle, be managed in two ways. First the price can be directly set at that level through regulation. This, however, assumes that regulators have sufficient information to determine marginal cost, which is unlikely, and that firms would not respond by refusing to enter the market. Second, the price can be controlled indirectly by allowing competitive generic entry. This could be done either by making pharmaceuticals unpatentable or, more realistically given current TRIPS obligations, by government grant of non-exclusive compulsory licenses. Of course, generic firms would need to enter the market for this approach to be effective and this cannot be assumed. Current international discussions over the patent system have broken down over the question of rules governing exports of generics into countries without their own domestic manufacturing capacity under compulsory license (the 'paragraph 6' debate). The way in which this impasse is resolved will influence the sources of generic supply for poorer countries and thus the likely competition among suppliers. In many countries there may also be other features of the market or regulation that limit competitive entry that are unrelated to patents.

What about prices below marginal cost? As we saw at the end of sub-section (3.1), Ramsey prices may well be less than marginal cost in some countries. At these prices firms would be selling at a loss. For a variety of reasons firms may be willing to do this in limited circumstances. Current drug donation programs are an example, although they do not fit the model here precisely since some part of the cost to the firm is offset by tax deductions. In general, we cannot assume that commerical firms will sell into markets at a loss and under current practice they would not be forced to do so by governments.. One potential way to implement such prices would be to link sales across countries through a bulk purchase arrangement, in the spirit of the large-scale procurement of vaccine by UNICEF, the United Nations' Children's Fund. Firms would tender to sell a given quantity of a pharmaceutical at a given uniform unit price to the intermediary, which would then sell the product to individual countries at differentiated Ramsey prices.[26]

A number of problems plague the use of such a scheme, however. Such sys-

[26] Under current practice, UNICEF purchases vaccines primarily for distribution in developing countries, so the potential cross subsidy or marginal costs from richer countries is limited.

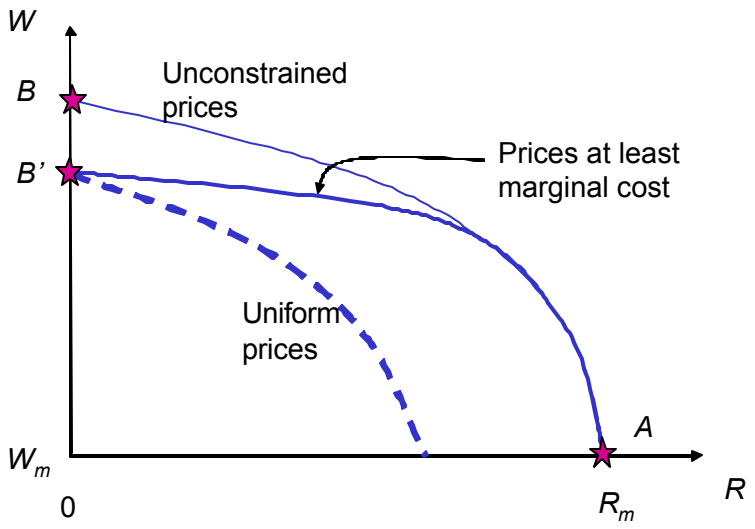

Figure 2: Limitations on prices shrink the feasible set of (R, W) pairs. At $R = 0$, the highest attainable welfare is at B', below B. Along the bold line, price must be at least as high as marginal cost, and along the dashed line, prices must be uniform across countries.

tems require an administrative infrastructure that would be costly to expand to a broad range of pharmaceuticals. Further, under such a scheme the richer countries in the arrangement effectively subsidize losses in the poorer ones, and this creates a clear incentive for firms and richer countries to interact directly.[27] Even if these difficulties could be overcome, it is would be hard for governments to credibly commit now to providing these sale arrangements for future new drugs, and therefore difficult to use them to encourage the right level of investment today.

Thus, as a practical matter, it may not be possible to implement prices lower than marginal costs even if it were desirable. We return to Figure 1 to consider what this limitation on pricing implies for our options. At point A the Ramsey price in each country is the monopoly price, which is greater than marginal cost. Thus the combination of revenue and welfare at point A remains feasible.

When the net revenue target is zero, only when $\beta_i = \beta$ for all countries are welfare-maximizing prices equal to marginal cost. (See discussion in section 4.1

[27] The obligation sometimes imposed on service providers, such as the postal service, to serve unprofitable locations or consumers at subsidized prices in order to obtain a larger contract is a domestic precedent for such an arrangement. The implicit subsidy from one group of consumers to another sometimes induces the former to opt out and purchase services from alternative suppliers (e.g., private postal services in the US). If it is not possible to control such parallel provision, it will be difficult to maintain a pricing structure that supports a cross subsidy.

and the appendix.) On the other hand, if there is a concern for distribution, Ramsey prices may be higher than marginal cost in some countries, and lower in others. If so, restricting prices to be at least as high as marginal cost in all countries would lower welfare in comparison to that attained with Ramsey prices, and the combination of R and W at point B would no longer be feasible. Figure 2 depicts the top portion of Figure 1. The upper boundary of the shaded area in Figure 2 now starts at point B', and indicates the highest level of welfare possible with each revenue target when all countries must cover their marginal costs. It is below the previous boundary - implying less attractive options - until the point where the required net revenue is sufficiently high that Ramsey prices also imply $p_i \geq c_i$ in all countries.

5.2 Limitations on Price Differentiation: Arbitrage and Reference Pricing

A second and far more restrictive limitation on pricing is a global uniformity constraint. While completely uniform prices are unlikely, there are two reasons why it might be difficult for a firm to charge markedly different prices for the same drug in different countries.

The first is arbitrage. Large price differences make it attractive for intermediaries to purchase goods in low-priced countries for sale in high-priced countries. The *Washington Post,* for example, describes how 18 million dollars worth of reduced price antiretroviral drugs meant for Africa were diverted back to the European market by black marketeers (October 3, 2002). With competition among intermediaries this activity will tend to narrow the differences in prices across countries. Without competition between intermediaries, prices may stay high in the high-priced countries but at least some part of the profit now goes to the intermediary. Either way revenue to the innovative firm falls.[28]

The second factor pushing global prices together is regulatory practice. In particular, many countries' price control boards refer to prices in other countries when determining their own price ceilings (so called "reference pricing", see Jacobzone, 2000).

Figure 2 illustrates how options are constrained, and welfare diminished, if we are limited to choosing a uniform price across all countries. With this restriction on pricing, the available combinations of welfare and revenue are now largely limited to those on the dashed line drawn inside the constrained boundary (which is in bold).[29][30] In general, the monopoly revenue R_m is no

[28] In practice, costs of intermediation allow for some limited differentiation even when arbitrage is legal (See Ganslandt and Maskus, 2002, for recent evidence within the EU). Intermediation becomes considerably more difficult if the transshipments are illegal.

[29] In addition the set of possible (R, W) points will include some single points below the boundary, because the non-monotone relationship between profit and price varies across countries.

[30] Moving to a uniform price within a *subset* of countries may increase welfare if it brings the structure of prices more closely into line with Ramsey prices. In particular, if drug prices are high in a very poor country there could be welfare gains from allowing imports to drive prices there down closer to the level of other poor markets.

longer possible because it requires different prices across countries.

Recognizing the welfare cost of having a single worldwide price, the European Union has initiated an enforcement effort to enable firms to differentiate ("tier") prices to the benefit of poor countries without being damaged by illegal arbitrage. The system will allow firms to register approved tier-priced drugs and mark them as such with an identifiable logo. Customs authorities will then detain marked products as they come into the EU until their status had been determined. The broader proposal also recognizes that rich countries must avoid reference pricing that includes poor country markets if price differences are to be maintained.[31] Although it is too early to know whether this particular system will be successful, it is clear that allowing greater flexibility in the menu of drug prices across countries is likely to enhance welfare.

5.3 TRIPS

As a result of the TRIPS component of the treaty establishing the WTO, all member countries are expected to grant and enforce twenty-year patents on pharmaceutical innovation. As most rich countries already offer such protection, the main result of TRIPS is to strengthen pharmaceutical patent rights in a group of poorer countries. Figure 3 illustrates the effects of this change, in the context of a product that has a worldwide market because it treats a disease with global incidence (e.g., cancer). Figure 4 portrays the case of a pharmaceutical product which is specific to the developing world. We present both here because the incentive and welfare tradeoffs posed by these two types of products differ significantly.

Point D in Figure 3 indicates a possible "pre-TRIPS" location for a global product. Firms have patent rights (often with price control) in most countries, with generic competition in some poor countries. Both regulation and competition push firm net revenue below R_m. At this point welfare is also lower than it need be, given R, because the global prices that result from the current system of uncoordinated national price regulation and free market pricing are unlikely to correspond to Ramsey prices for any social welfare function. In particular, it has been observed that the price of a drug can be higher in a poor country than in richer countries - that is, the positive correlation that one would expect between per-capita income and price is weak.[32] Prices may not correspond closely to income levels because price regulations are less effective in poorer countries or because it can be profitable for a firm to target just the upper class in a poor country with a very unequal income distribution. Whatever the reason, this structure of pricing is unlikely to reflect a distributionally sensitive welfare function for the reasons discussed in section (3). At the same time, this structure

[31] The scheme would apply only to drugs for certain diseases, priced according to specific rules, and coming from a limited set of countries. See the October 2002 proposal at http://europa.eu.int/comm/trade/csc/med.htm (accessed April 9, 2003), and announcement of program adoption at http://europa.eu.int/comm/trade/csc/med08_en.htm (accessed May 26, 2003).

[32] See, for example, the Scherer and Watal (2002) study of anti-retroviral drugs.

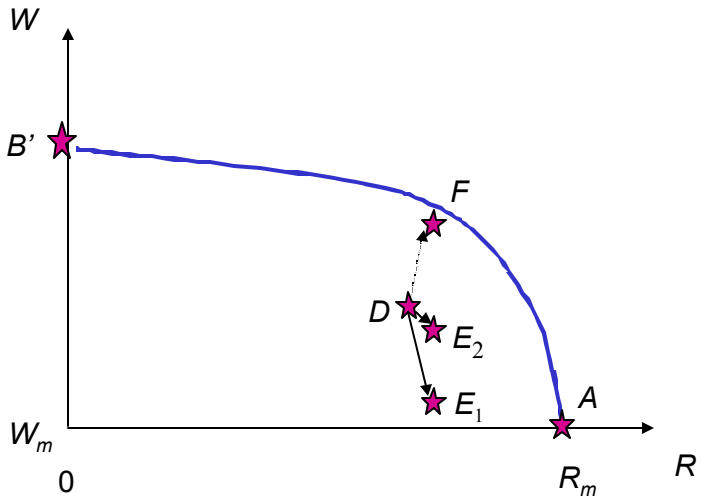

Figure 3: The effect of TRIPS is to induce a move from pont D to a point like either E_1 or E_2, at which welfare is lower, and revenue is very marginally higher. An alternative would be to move to a point like F, which allows the same increase in revenue, but with a positive impact on welfare.

of prices also does not reflect what we have called "standard" Ramsey prices because the existing mark-ups are not proportional to monopoly mark-ups.

The introduction of TRIPS results in a move to one of the points denoted E. This extension of the global patent system has two implications. First, by adding patent rights in some developing countries, and strengthening them in others, the net revenue generated from sales on any given product increases. But note that it increases very little because the markets in poor countries are exceedingly small even though they have large numbers of people. Lanjouw (2002) estimates, for example, that countries with half of the world's population represent less than two percent of spending on cardiovascular drugs. For this reason firms often choose not to patent in poor countries even when they are able to do so (Attaran and Gillespie-White, 2001). The small size of the net revenue gain does not depend on the particular social welfare function adopted, so we indicate all possible "post-TRIPS" points E as a small distance to the right of D.

Second, the structure of contributions changes such that a greater share of the total net revenue received by firms is obtained from sales in poorer countries. Note that prices in some countries are higher with TRIPS and nowhere are prices lower. Therefore welfare certainly decreases and all points E are at a lower welfare level than the pre-TRIPS point D. How much welfare falls, however, depends on the precise social welfare function used. Because it is relatively poor countries that will have higher prices as a result of TRIPS, a

welfare function with any aversion to inequality would suggest that welfare falls steeply, as indicated by E_1 in the figure. On the other hand, if there is little concern for distribution then the welfare fall may be moderate, as indicated by point E_2.

This figure illustrates an important question regarding the purpose of TRIPS that should be made explicit. If the purpose to increase the relative *share* of global research costs paid by poor countries so as to be somehow "fair", then it would seem reasonable to keep net revenue at the pre-TRIPS level of point D by pairing the new patent regime with stronger price control in the rich countries (i.e. lower prices). Alternatively, if the purpose is to increase - slightly - the net revenue received by an innovating firm on a given product, then it would seem worthwhile to consider whether strengthening patent rights in poorer countries is the best way to do this. There are, after all, many alternatives. One could target point F, for example, which would require moving prices in rich countries into closer correspondence with Ramsey prices. At the most basic level this means that those with similar income levels and demand patterns should have similar mark-ups. Thus moving to Ramsey prices would require prices to go up in some of the high- income countries that have restrictive controls and to come down in some of the countries with relatively high drug prices (e.g. the U.S.). The latter is what allows welfare to be higher at F as compared to point D. A second alternative would be to enhance other sources of research support (i.e., raise the value of T rather than the value of R). For example, the returns received by firms on innovative products could be raised by offering them higher R&D tax credits.

We now turn to the particular case of a product that is specific to developing countries, which is depicted in Figure 4. For simplicity it is assumed to have no market outside of these countries. We begin at point C where the given product - e.g. a therapy or vaccine for malaria - does not exist. Clearly, if non-revenue sources of research support are, by themselves, sufficient to have the product invented (i.e., $T \geq V$) then there is no reason to allow a margin on sales and optimal prices would lead to point B. In this case it could be damaging to welfare to grant patent rights in the poor countries.

However, it seems unrealistic to assume that this will typically be the case. Indeed, those closely involved in trying to better health conditions in the developing world often stress the enormous gap between the human suffering caused by developing-country specific diseases and the relatively low level of public and philanthropic investment to discover products to treat them.[33] Since there does not seem to be good reason to expect a dramatic change in public sector priorities, point B simply may not be possible. That is, there may need to be some contribution coming from consuming countries in the form of net revenue in order to reach the level of incentive V required for the desired innovation to happen. Without any additional incentive society might remain at point C.

With the implementation of TRIPS, a firm inventing a product would be able

[33] See, for example, the reports of the Médecins Sans Frontières Working Group on Drugs for Neglected Diseases at http://www.accessmed-msf.org/dnd. It is estimated that almost a million children die each year from malaria.

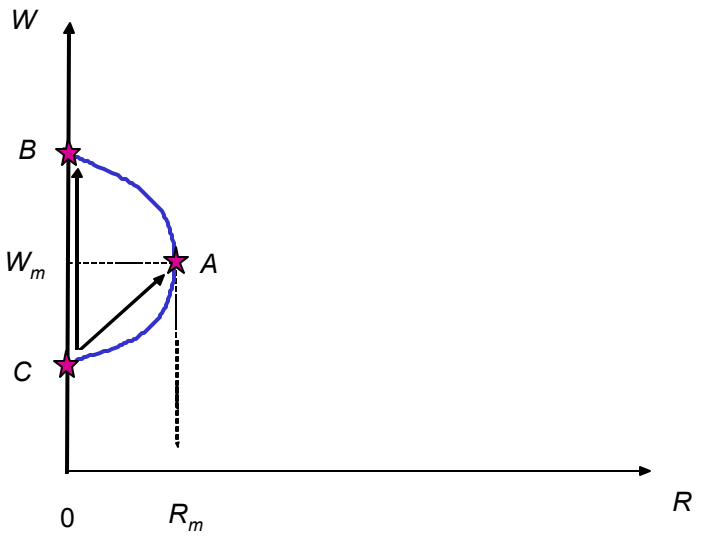

Figure 4: The case of a tropical disease. Before an innovation, we are at point C. Strengthening patent rights in poor countries might move us to point A, if the revenues generated are sufficient to finance the requisite R&D. Alternatively, R&D by taxpayers would lead to point B.

to obtain monopoly profit in each poor country (assuming, again for simplicity, no price control) with a total denoted R_m as before. Although R_m is smaller than the net revenue generated by a global product, in some cases it could tip the balance such that $T + R_m \geq V$ and new investments are made. Thus, *for products specific to the developing world* there is a rationale for having patents in the poorer countries.[34] If the patent rights lead to new innovation in this neglected area, then post-TRIPS we move from point C to point A and welfare improves. If no new products result then also no patents will be issued to protect them and welfare is unaffected.

6 Conclusion

In this paper we have employed the techniques of modern public finance to consider how pharmaceutical prices should be set in a global context. In particular, we have considered how extreme inequality in the distribution of world income, coupled with a concern therefor, leads to adjustments to standard pricing prescriptions. With these adjustments, poor countries should not necessarily cover their own marginal costs of drug production and distribution. In particular,

[34] See Lanjouw (2002, 2003) for a mechanism that allows different global patent rights for different diseases.

these countries should not necessarily share in any of the costs of R&D. Also, the pricing structure is not related to that which would be chosen by a monopolist in a simple (proportional) way. Both of these results are at odds with standard analyses which do not take explicit account of distributional concerns.

We have been careful to distinguish between general tax sources for financing R&D incentives, and sales revenues, although we have said little about what the split between these two sources should be. We recognize explicitly that private sector R&D cannot be treated as free, and while there might be ways of limiting the economic rents earned by pharmaceutical companies (e.g., through various contractual mechanisms), in the end the costs of R&D must fall either on taxpayers in general or consumers of the product. Our paper essentially looks at how these costs should be distributed across different types of consumers.

A serious problem that arises with many development assistance programs is that of within-country targeting. We have abstracted from this issue, by assuming that all individuals in a given country are identical, but in practice, there is likely to be a concern that at least some of the benefits of low drug prices in poor countries might accrue to local elites. This might occur for two reasons: first, lowering prices for drugs already consumed by the elite gives them a direct benefit; and second, if members of the elite can act as intermediaries, they might be able to appropriate some of the benefits of lower (import) prices. We recognize these effects, but expect that at least some of the benefits would reach the poor, especially if low prices are implemented through competition and not by regulation.

Finally, we have used the framework to examine recent changes to, and on-going debates regarding, the international patent system as embodied in the TRIPS agreement. Holding R&D incentives fixed, the welfare impact of the TRIPS is likely to be negative. On the other hand, the very small net revenue increase that TRIPS might afford pharmaceutical companies (thereby strengthening R&D incentives) could be implemented in an alternative fashion with a positive welfare effect.

7 Appendix

We demonstrate graphically that in the special case where $\beta_i = \beta$, optimal prices are such that the price in each country is at least as high as c_i, the marginal production and distribution cost there. We also show that when β_i's are not the same across countries, the price in one country may be lower than c_i. Return to the discussion immediately following equation (3). There it was argued that the marginal social cost of raising additional net revenue in country i is the ratio of $-\frac{\partial W}{\partial v_i}\frac{\partial v_i}{\partial p_i}$ to $\left(y_i + (p_i - c_i)\frac{\partial y_i}{\partial p_i}\right)$. Using (1), this ratio is just

$$\frac{MSC_i}{MR_i} = \frac{\beta_i y_i}{\left(y_i + (p_i - c_i)\frac{\partial y_i}{\partial p_i}\right)} \tag{12}$$

This ratio is just the change in social cost from raising an additional dollar in country i, $\frac{dSC_i}{dR_i}$, at a price p_i. At the optimal prices, the marginal social cost of raising revenue is equalized across countries: $\frac{dSC_s}{dR_s} = \lambda = \frac{dSC_n}{dR_n}$. Note that when the price in country i is just equal to production cost c_i there, the expression (12) collapses to

$$\frac{MSC_i}{MR_i} = \frac{dSC_i}{dR_i} = \beta_i. \tag{13}$$

Two cases are shown in Figure 5. Begin with panel A. The length of the horizontal axis represents the total net revenue of R in excess of marginal production costs to be raised from sales in all countries. Through the choice of prices, this revenue target can be divided between the two countries, with the amount raised in country n measured from the left and that raised in country s measured from the right. The horizontal dashed line in the figure is at the level of marginal cost, which we assume here is the same across countries: $c_n = c_s = c$. Generating revenue in either country imposes a social cost. First consider the social cost when revenue is raised in the south. We start with $p_s = c$. At this point revenue from the south is zero and we are on the right-hand edge of the figure. We know from (13) that the marginal social cost of generating an additional unit of revenue at this point is β_s. The cost increases as we move left and more revenue is generated in country s via increases in p_s. The same comments apply for the north but starting from the left-hand edge of the figure. This gives the two marginal social cost curves. In Panel A, $\beta_n = \beta_s$, so the curves necessarily cross at some point in the middle of the figure. This means that both north and south contribute to the revenue requirement in amounts R_n^* and R_s^* respectively, and prices in each are above marginal cost.

In Panel B we assume that $\beta_n < \beta_s$. Now it is possible that the two curves representing marginal social cost cross at a point *outside* the interval shown. This simply means that the net revenue requirement, R, should be "shared" between the two countries by having country n contribute $R_n^* > R$, while country s receives a subsidy in the amount of $R_s^* = R_n^* - R$, by paying less than the marginal cost of production.

References

[1] Atkinson, Anthony and Joseph Stiglitz (1976): "The design of tax structure: direct versus indirect taxation," *Journal of Public Economics*, 6: 55-75.

[2] Atkinson, Anthony and Joseph Stiglitz (1980): *Lectures on Public Economics*, McGraw-Hill.

[3] Attaran, Amir and L. Gillespie-White (2001) "Do Patents for Antiretroviral Drugs Constrain Access to AIDS Treatment in Africa," *Journal of the American Medical Association*, Vol. 286, no. 15, pp. 1886-92.

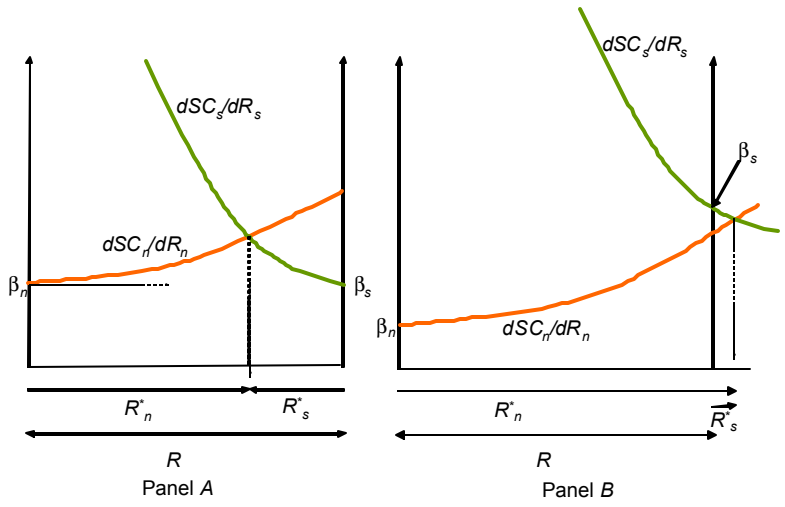

Figure 5: Marginal social costs of revenue generation in countries n and s.

[4] Baumol, William and David Bradford (1970): "Optimal departures from marginal cost pricing," *American Economic Review*, 60: 265-283.

[5] Danzon, Patricia M. (2001) "Differential Pricing for Pharmaceuticals: Reconciling Access, R&D, and Patents" Commission on Macroeconomics and Health, WHO. Working Paper series no. WG2: 10.

[6] Danzon, Patricia M. (1997) "Price Discrimination for Pharmaceuticals: Welfare Effects in the US and the EU," *International Journal of the Economics of Business*, Vol. 4, no. 3, pp. 301-21.

[7] Diamond, Peter (1975): "A many-person Ramsey tax rule," *Journal of Public Economics*, 4: 335-342.

[8] Diamond and Mirrlees (1971): "Optimal taxation and public production II: tax rules," *American Economic Review*, 61: 261-278.

[9] Ganslandt, Mattias and Keith Maskus (2002) "The Price Impact of Parallel Trade in Pharmaceutical Products: Evidence from the European Union," Mimeo. University of Colorado.

[10] Jacobzone, S (2000) "Pharmaceutical Policies in OECD Countries: Reconciling Social and Industrial Goals," Labour Market and Social Policy - Occasional Papers No. 40. OECD, Paris.

[11] Kopczuk, Wojciech, Joel Slemrod, and Shlomo Yitzhaki (2002) "Why World Redistribution Fails," NBER Working Paper 9186, National Bureau of Economic Research.

[12] Lanjouw, Jean.O. (2003) "Intellectual Property and the Availability of Pharmaceuticals in Poor Countries," *Innovation Policy and the Economy*. Vol. 3, pp. 91-130 (MIT Press: Cambridge, MA).

[13] Lanjouw, Jean. O. (2002) "A Patent Policy for Global Diseases: U.S. and International Legal Issues," Harvard Journal of Law & Technology. Vol. 16., no. 1. Fall, pp. 85-124.

[14] Nordhaus, William (1969) *Invention, Growth and Welfare* (Cambridge: MIT Press).

[15] Ramsey, Frank (1927): "A contribution to the theory of taxation," *Economic Journal*, 37:47-61.

[16] Scherer, F.M. (2003) "Global Welfare in Pharmaceutical Patent Policy," Mimeo. Princeton University.

[17] Scherer, F.M. (1972) "Nordhaus' Theory of Optimal Patent Life: A Geometric Re-interpretation," *American Economic Review*. Vol. 62, Issue 3. pp. 422-7.

[18] Scherer, F.M. and Jayashree Watal (2002) Post-TRIPS Options for Access to Patented Medicines in Developing Nations," *Journal of International Economic Law*, pp 913-39.

[19] World Bank (2003): *World Development Report*, Oxford University Press, Washington DC.