Transparency and Credible Commitment:
Most-Favored-Customer Provisions and the Sustainability of Price Discrimination

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Published in ***International Journal of Trade and Global Markets*** (2013), **6**(3): 275–300,
www.inderscience.com/info/inarticletoc.php?jcode=ijtgm&year=2013&vol=6&issue=3.

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ABSTRACT: Lump-sum rebates can protect price-discriminators against reselling. Large customers, however, can bargain for a larger rebate. This paper shows how sellers can make a credible commitment to not bargain: a price discriminating formula is published as a Most-Favored-Customer (MFC) contract: if any MFC gets a rebate greater than specified by formula, so do all. The larger the rebate asked for, or the finer the degree of discrimination, the more groups affected by deviations from this formula. Thus the seller loses more revenue. Incentive and welfare effects are illustrated with global incomes data. *JEL Codes: D40, F12, 015*

Introduction

That price discrimination is efficiency improving compared with a single price monopolist is well known. That it may also promote equity – by improving access for poorer consumers – is only slightly less well known. It may even be Pareto-improving, as Schmalensee (1981) proves, and as shown in a pedagogical experiment by one of the authors in Basuchoudhary *et. al.* (2008).

Examples of price discrimination are well-known: airline tickets, health insurance, and software. Internet retailers like Amazon regularly engage in price discrimination (Heffernan, 2010). But price discrimination can be resisted: Low-price customers can resell for a higher price (so-called *parallel-trade*, or *re-exporting*). High-price customers can also bargain by pointing to lower prices elsewhere (*reference pricing*). Either tactic can stop effective price discrimination. Our paper considers how such retaliatory measures can be effectively countered.

The international market for pharmaceuticals, which we take as our focus, is one of the best known kinds of price discrimination. Different prices in emerging and developed country markets are standard for pharmaceutical corporations. Developed countries are where most profits are generated, yet the developing world shows faster growth.[1] The pharmaceutical industry aims to capture both: "not only the premium markets but … sales to a wider customer base." The problem, however, is that low prices in the latter can leak into the former. Price discrimination "must be achieved while simultaneously preventing negative impacts – such as reference pricing or inappropriate parallel trade – in established markets." (Pharma Futures 2, 2006, p. 32)

There is recent empirical evidence (Kyle, 2011) that pharmaceutical companies in the EU take a variety of non-price measures to thwart parallel trade: product and package differentiation, refusing to sell certain products to some countries, or discontinuing some products entirely. While such measures inhibit parallel trade, Kyle (2011) notes that they also impose costs on both companies and consumers, compared with 'clean' price discrimination.

Reference pricing and parallel trade take place in an international market characterized by bilateral monopolies and imperfectly segmented markets – patent-backed sellers facing single-payer government buyers (DuMoulin, 2001; Danzon and Towse, 2003). Danzon and Towse show that reference pricing and parallel trade are used mostly by governments in developed and developing countries, respectively. Of the 27 countries of the EU, for example, 24 reference pharmaceutical prices in other member states; Germany, Sweden, and the UK are the exceptions (GABI, 2011). Ending price discrimination, however, can hurt most consumers – as Danzon and Towse (2003) and a recent report of the European Parliament (Kavanos *et. al.*, 2011) argue.

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[1] IMS, a leading pharmaceutical market research firm, reports that China, the third-largest pharmaceutical market, will combine with 16 other emerging markets to account for half of global pharmaceutical growth by the middle of this decade (Gatyas and Savage, 2010).

Welfare improvement from price discrimination usually assumes willingness to trade off at least a small amount of efficiency for greater equity (Atkinson, 1970; Okun, 1975). Welfare issues are complex, but some of the most common objections to Country-based price discrimination – that it means higher prices to the poor within rich countries, and lower prices to the rich within poor countries – are best addressed by *further* discrimination, a more fine-grained focus on differences *within* countries. The numerical simulations of this paper show that the majority of consumers, including those in rich countries, can benefit from such moves.

For incentivizing against parallel trade *resale*, we propose a lump-sum rebate to a named customer-government. In order to prevent any reference price *bargaining* over the size of this rebate, we propose a Most-Favored-Customer (MFC) clause, analogous to the Most-Favored-Nation agreements common to international trade. MFC provisions have long been used to *counteract* price dispersion, enforcing a monopolist's single price (Neilson and Winter, 1994). As such, they are usually seen as an *alternative* to price discrimination (Png, 1991). Similarly, Kyle and Ridley (2007) argue that World Health Organization (WHO) demands for greater transparency in pharmaceutical pricing will likely strengthen price uniformity, thus hurting the poorest groups. By contrast, we show here that a transparent policy of MFC *plus* Price Discrimination (=MFCPD) can help *maintain* price dispersion – through the seller's commitment to a *published formula* for *income-based price discounting*. This idea of MFCPD originates with our paper, as far as we know.

Discounting is via a lump-sum rebate to the final purchaser, based on the same published formula. Since this rebate is based on a prior *estimate* of demand, independent of current purchases, it cannot affect marginal cost. The latter is the same for all buyers, removing the opportunity for resale.

An alternative to lump sum rebates is used by Danzon and Towse (2003). Unlike the present paper, their incentive innovation is for these rebates to be *secret*:

> If discounts to low income countries or market segments are given as confidential rebates paid directly to the ultimate purchaser, while wholesalers are supplied at a common price (or act as distribution agents who do not own the product), this eliminates the opportunity for other purchasers to demand similar rebates. It also eliminates the opportunity for wholesalers or other parallel traders to purchase the product at the low price intended for low-income countries and export it to higher-price countries, and prevents leakages of products between market segments within countries, confining discounts to the intended beneficiaries. Confidential discounts are the chief means by which US managed care purchasers get lower prices…

The above formulation attributes two incentive properties to the secrecy of the rebates, but shows only one. The first sentence correctly notes that reference pricing pressure is absent if discounts are secret. We will argue that keeping such a secret is highly problematic, but there is another problem. The second sentence claims that confidential rebates 'also eliminates the opportunity' for parallel trade. But consider my purchase of a good discounted by one-half of its fixed global price P. The fact that my discount is secret does not stop me from reselling at any price between P and P/2. I may even *prefer* secrecy: it makes it easier for me to ask for a price well above P/2. Thus secrecy eliminates reference pricing, not parallel trade.

In fact, it is the *lump-sum* and *named consumer* aspects of standard rebate practice – and not secrecy *per se* – that provide incentives against reselling.

a) A *lump-sum transfer* does not vary with volume of purchase, and so cannot affect the price at which new units of the drug are purchased – the undiscounted fixed World price. It eliminates the gain from reselling *newly purchased* units of the drug below that price.

b) The fact that this rebate is to a *named consumer* – a household, a health clinic, or a national government – means that only a limited amount of the drug can be credibly self-consumed.[2]

[2] One can also require evidence of consumption by the named party – prescriptions, sales receipts, etc.

Both the lump-sum and the named consumer aspect are captured by the ‘mail-in rebates’ of many marketing campaigns. Such rebates are usually for specified quantities (e.g., one-to-a-customer). (Note that a percent-of-purchase-price and a lump-sum rebate are equivalent if they are for the same value and the same fixed number of units.)

While secrecy could prevent reference pricing, we are skeptical of the ability of most governments to keep such secrets. The record on diplomatic secrets is not encouraging, even though the sensitivity of such secrets may be greater. Rebate secrets would be more in demand, and easier to monetize than diplomatic secrets – most countries would have a direct interest. Since disclosure is likely anyway, we propose a transparent price discrimination formula, making a virtue of necessity.

Our paper is organized as follows. Section I gives describes the rebate process through which discrimination is realized. Section II places our Most Favored Customer Price-Discrimination (MFCPD) contract in the context of the literature on MFC contracts. Section III presents our model of a MFCPD contract. We show that under MFCPD, even the largest customer (the US) would need to promise a curtailment of several times its own purchases in order to threaten more harm to the Seller than having to grant the same discount to everyone. Section IV argues for Marshallian Consumer Surplus as the most practical measure of consumer welfare here for its conservatism (understatement of welfare gains), transparency, and robustness to estimation errors. Section V shows that the Company’s refusal to negotiate under MFPCD is sub-game perfect. Section VI introduces a Proposition strengthening the incentive compatibility of MFPCD – that a Country’s minimum effective threat of curtailed purchases becomes more stable with finer degrees of price discrimination. Section VII illustrates these points with a numeric example based on global income distribution. Section VIII gives conclusions. Appendix 1 calculates the Willig (1976) error bounds on Consumer Surplus, and Appendix 2 proves the Proposition of Section V.

I. Price Discrimination as a Rebate Process

If the government of Country i[3] (referred to here as 'the Country') must buy the goods at the *fixed World price* $\underline{\underline{Pw}}$, then its optimal per-unit rebate, r_i, is the difference between the seller's profit-maximizing price to i, P^*_i, and $\underline{\underline{Pw}}$:

$$r_i = \underline{\underline{Pw}} - P^*_i \,. \tag{1}$$

(Note that $\underline{\underline{Pw}}$ may be set arbitrarily high, as in a common marketing ploy, so that *every* customer receives a rebate.) The *total* rebate of the Country, is

$$R_i = r_i Q^*_i \,, \tag{1a}$$

Where Q^*_i is the *estimated* amount purchased at optimal price P^*_i, one that maximizes profits for the seller. We abstract from time, thus assuming rebates are given at the time of purchase.

The seller (referred to here as 'the Company') estimates and publishes formulas for discrimination, using data relevant to the Country, such as provided by the IMF and World Bank. The formula is based on an ex-ante *estimate* of demand Q^*_i, making the rebate R_i *lump-sum* and independent of the quantity of goods purchased ex-post. For simplicity, transparency, and incentive compatibility, each Country must use the same formula – the only difference is Country-specific variables. In the example below we limit these to the Country's per-capita income and population. Other demand factors could also be used, for example public data on age structure, disease incidence, or income distribution. *Public* data are required because the formulas must be simple to verify. This is not how price discrimination is usually carried out, which is very much in secret – as Danzon and Towse (2003) advocate.

[3] As Danzon and Towse (2003) note, governments are by far the most important purchasers of most pharmaceuticals. Thus we are assuming monopsony power within each purchasing country.

II. A 'Most-Favored-Customer Price-Discrimination' (MFCPD) Contract

Our Most Favored Customer Price Discrimination (MFCPD) contract prohibits 'second stage' price discrimination. Having made public the formula for *first stage* discrimination, the contract would punish any *second stage* discounts – deviations from this formula – by forcing the seller to grant the same to all MFCs. Thus, as is well known (Cooper, 1986; DeGrabba, 1996; Saggi, 2005), the company's MFCPD 'promise' becomes a *credible threat* to not negotiate – in the sense of *sub-game perfection* (Gardner, 1995). We will illustrate this in the form of a simple game, and in a numerical example based on international data.

The Company announces to the world that each Country will be offered a rebate on the basis of (1a), where the derivation of consumption Q^*_i (see equation (2c) below) is estimated on the basis of public data. This rebate is offered as a take-it-or-leave-it proposition. The Company also offers each Country a contract with a MFCPD clause. This states that if it can be proven – in a previously agreed-upon court – that the Company has given some other Country terms *more favorable* than those under the MFCPD formula, the Company must then immediately grant equally favorable terms all MFCs.

Equivalent language in every contract makes credible the Company's commitment to not negotiate any contract. The risk of secretly negotiating an additional discount is the collapse of its system of take-it-or-leave-it rebates. Providing a customer-driven rebate, even to a large Country with real market power, could be worse for the Company than its default to a single-price monopoly.

It is worth re-emphasizing that this price discriminating use of MFCPD clauses is the *opposite* of most MFC clauses. These are common for enforcing *single price* monopoly power for the selling Company, as are MFN clauses for exporting nations (Cooper, 1986; Neilson and Winter, 1994; Ping, 1991; DeGraba, 1996; Saggi, 2004). Thus MFC clauses are used to enforce a single-price monopolist's goal of price *uniformity*. Our MFCPD is a tool for price *discrimination*.

III.1 A Model of MFC Price Discrimination (MFCPD)

Let the quantity demanded for a product in Country i, Q_i have a simple linear estimate

$$Q_i = Pop_i\{\alpha - \beta P_i + \gamma Y_i\}, \tag{2}$$

where P_i is price set by the Company, Y_i is the discriminating indicator (Per Capita GDP), and Pop_i is population of Country i. The estimated parameters (α, β, γ) are positive, so Q is a normal good. It should be noted that this form is highly restrictive, imposing identical parameters α, β, and γ, on all Countries i. A closer fit could be achieved if we allowed these parameters, and even functional form, to vary between Countries – as in most studies of international price discrimination (Adrian and Towse, 2003).

The reason for this restriction is simple. The MFCPD proposed in this paper must be public and *transparent*; i.e., easily verified. Thus it is best accomplished by a *single* formula with unique parameters. Equation (2) can be re-written with Price as the dependent variable:

$$P_i = \{\alpha + \gamma Y_i\}/\beta - Q_i/\beta Pop_i. \tag{2a}$$

In (2a), γ/β can be interpreted as the public discount on income – a dollar less per-capita income Y_i makes the unit price P_i γ/β dollars lower. Let the marginal cost of the product per unit be μ, so that profits to the Company (i.e., Producer's Surplus, ignoring fixed costs for R&D) are:

$$\pi_i = (P_i - \mu)Q_i = (P_i - \mu)Pop_i\{\alpha + \gamma Y_i - \beta P_i\}$$

Taking the derivative of π_i with respect to P_i, first-order conditions for profit-maximization are

$$\alpha + \gamma Y_i - 2\beta P^*_i + \mu\beta = 0 \;\Rightarrow$$

$$P^*_i = (\alpha + \gamma Y_i + \mu\beta)/2\beta, \tag{2b}$$

the charge to Country i by a price discriminating monopolist. From this we get the difference between the price discriminating P^*_i and the fixed World price $\underline{\underline{Pw}}$ as shown in (1) and (1a):

$$r_i = \underline{\underline{Pw}} - P^*_i ,$$

$$Q^*_i = Pop_i\{\alpha - \beta P^*_i + \gamma Y_i\}, \text{ and}$$

$$R_i = r_i Q^*_i , \tag{2c}$$

where R_i is the lump sum rebate to Country i. If the Company were to violate MFCPD and grant a lower price for one Country i, we would have in effect a *revised* coefficient on income in formula (2b), $\gamma' = \gamma + \Delta\gamma$, where $\Delta\gamma < 0$, yielding $P'_i < P^*_{i.}$ We then have the formula for the revised per-unit price to Country i:

$$\Delta P_i = P'_i - P^*_i = (\gamma' - \gamma)Y_i/2\beta = \Delta\gamma Y_i/2\beta < 0. \tag{2d}$$

III.2 <u>Credible commitment for the Company under a Public Formula for Discrimination</u>

If the price discrimination formula is truly fixed, there is nothing more Country i can do to raise its rebate. This begs the question, however, of whether there is anything Country i can do to *change* this formula, to get a larger rebate based on its market power.

Say that Country i bargains for a price cut by threatening to cut its purchases, and that this reduction would lower the Company's profits from that Country by more than the price cut itself. If the Company accedes to this threat, then π^*_i , the optimal profits it would have had from i under full discrimination:

$$\pi^*_i = (P^*_i - \mu)Q^*_i = (P^*_i - \mu)Pop_i\{\alpha - \beta P^*_i + \gamma Y_i\}, \tag{3a}$$

will be lowered to $\pi'_i < \pi^*_i$:

$$\pi'_i = (P'_i - \mu)Q'_i = (P'_i - \mu)Pop_i\{\alpha - \beta P'_i + \gamma Y_i\}. \tag{3b}$$

Notice that in (3b), we use the original estimate of the behavioral parameter γ, and not the revised price-cut formula value $\gamma' < \gamma$. This is because from (2d), what has changed is the price,

$$\Delta P_i = P'_i - P^*_i = (\gamma' - \gamma)Y_i/2\beta < 0,$$

and not the parameters estimating Country i's actual response to that price.

Starting from π^*_i but moving to $\pi'_i = \pi^*_i + \Delta\pi_i$ (where $\Delta\pi_i < 0$, by prior maximization), and taking the derivative of (3a) with respect to price, we can show the effect of a small change dP_i is

$$d\pi_i = dP_i\, Pop_i[\{\alpha - \beta P^*_i + \gamma Y_i\} - \beta(P^*_i - \mu)]$$

$$= dP_i\,[Q^*_i - \beta Pop_i(P^*_i - \mu)Pop_i] < 0, \qquad (4)$$

where the final substitution uses $Q^*_i = Pop_i\{\alpha - \beta P^*_i + \gamma Y_i\}$, from (2c). The expression $d\pi_i$ in (4) can be seen as the change in price $dP_i < 0$ times (i) the original quantity sold under the old contract, Q^*_i, (ii) plus the marginal increase in per-capita purchases from lower prices ($-dP_i\beta > 0$), as multiplied by (iii) the original profit margin and population, $(P^*_i - \mu)Pop_i$.

What sort of price-cut pressures can the Company resist? We will show that it cannot be effective for a Country to threaten a reduction in purchases that is "too small." To make this more precise: the threatened reduction in Company profits from Country i, $\Delta\tilde{\pi}_i < 0$, should be larger in absolute value than that implied by the asked-for price change, $\Delta\pi_i < 0$. To be minimally effective, this $\Delta\tilde{\pi}_i$ must be large enough in absolute value that:

$$\Delta\pi_i - \Delta\tilde{\pi}_i > 0,$$

so the Company has an interest in avoiding it. A MFCPD contract will be *incentive compatible* for the Company – i.e., will stop the Company from agreeing to any price-cut with Country i – when the decreased profits from all *other* Countries would be so large that, despite the previous inequality:

$$\Delta\pi_i - \Delta\tilde{\pi}_i + \sum_{j\neq i}\Delta\pi_j < 0. \qquad (5)$$

If the threatened reduction in profits $(-\Delta\tilde{\pi}_i) > 0$ is too small, it will be overwhelmed by the other two negative terms, and the negativity of (5) will be preserved – so it is credible that the Company will not renegotiate. Only a loss $(-\Delta\tilde{\pi}_i)$ large enough to reverse the sign of (5) can be an effective threat.

This implies that even a country as large as the US could turn (5) positive only by threatening a reduction in profits $\Delta\tilde{\pi}_i$ more than twice that implied by its asked-for discount. To see this, note that for any Country i, an effective threat $\Delta\tilde{\pi}_i < 0$ must be at least τ_i times as great as its asked-for profit reduction, $\Delta\pi_i < 0$, so that $-\Delta\tilde{\pi}_i$ is large enough to reverse the sign of (5). A successful 'threat multiplier' τ_i will thus need to satisfy

$$\tau_i \equiv \Delta\tilde{\pi}_i / \Delta\pi_i > 1 + \sum_{j\neq i} \Delta\pi_j / \Delta\pi_i > 1 \tag{5a}$$

As the world's largest economy, the US accounts for 45 percent of OECD pharmaceutical spending[4] (OECD, 2010) and in the numeric example below, 38 percent of the world producer's surplus for a pharmaceutical product. Using 45%, (5a) yields $\tau_i > 1 + (1-.45)/.45 = 2.22$; using 38% yields 2.63. For an economy smaller than the US, this threat multiplier would be greater still. Thus, if $\Delta\pi_i$ is worth winning for Country i, it must threaten a much larger harm to the Company. The obvious question is whether such a threat is credible. If Country i has to implement its threatened $\Delta\tilde{\pi}_i$, how large a fall in its consumer surplus would this imply?

IV. <u>Welfare Effects: Variation in Consumer Surplus</u>

From our estimate of the demand curve (2a), we can derive the familiar expression for the *consumer surplus* of Country i, which we will call θ_i, as the area of a right triangle with its height given by the vertical intercept minus P^*_i (shown in 2b), and its horizontal dimension by Q^*_i:

$$\begin{aligned}\theta^*_i &= Q^*_i(\{\alpha + \gamma Y_i\}/\beta - P^*_i)/2 \\ &= Pop_i\{\alpha + \gamma Y_i - \beta P^*_i\}(\{\alpha + \gamma Y_i\}/\beta - P^*_i)/2\end{aligned}$$

Evaluating dP at the initial P^*_i, we have the Variation in Consumer Surplus (VCS):

$$d\theta_i = -\,dP^*_i Pop_i[\,(\alpha + \gamma Y_i - \beta P^*_i) + \beta(\{\alpha + \gamma Y_i\}/\beta - P^*_i)\,]/2$$

[4] This estimate may be a bit high, however, since the OECD does not include several large developing countries such as Brazil, Russia, India, China, and South Africa.

$$= -\,[dP^*_i Pop_i 2(\alpha + \gamma Y_i - \beta P^*_i)]/2$$

$$= -\,dP^*_i[2Q^*_i]/2 \;\; = -\,dP^*_i Q^*_i \qquad (6)$$

Equation (6) accords with the intuition that a rise in prices ($dP^* = P_1 - P_0 > 0$) will lower consumer surplus, while a fall in prices ($dP^* < 0$) will raise it.

The coefficient on income in demand equation (2) is positive, as Q is a *normal* good. For a normal good, VCS is less than Equivalent Variation (EV) and greater than Compensating Variation (CV) (Varian 1992, p.168). EV is the value given (if positive) or taken (if negative) to achieve the same welfare as a *prospective* price change. CV is the value taken (if positive) or given (if negative) to compensate for a *completed* price change. Note that the ordering in (7) is independent of sign:

$$\begin{array}{ll} \text{For } \Delta P < 0: & 0 < CV_i(+) < VCS_i(+) < EV_i(+) \\ \text{For } \Delta P > 0: & CV_i(-) < VCS_i(-) < EV_i(-) < 0 \end{array} \qquad (7)$$

This makes VCS a *conservative* estimate of the *net welfare change* measured by EV. For a fall in prices, ($\Delta P < 0$), $VCS_i(+)$ is conservative in the sense of showing *less benefit* than $EV_i(+)$. For a rise in prices ($\Delta P > 0$), $VCS_i(-)$ is conservative in the sense of showing *more harm* than $EV_i(-)$. Summing the columns of (7) over all i, the sum of EV_i is clearly more than VCS_i:

$$\sum_i CV_i(+) + CV_i(-) \;<\; \sum_i VCS_i(+) + VCS_i(-) \;<\; \sum_i EV_i(+) + EV_i(-)\,. \qquad (7a)$$

By (7a), if the sum of VCS is positive, the sum of EVs must be even more so. So a positive VCS is a conservative estimate of *positive* EV, or prospective improvement in net welfare.

Despite this, why not just compute EV directly, as in Mervyn King's (1983) study of proposed tax reforms? VCS avoids several estimation difficulties posed for the exact measures: integrability restrictions (Begin *et.al.,* 2003; Just and Gilligan, 1998; Creedy, 2006), non-linear expected values (Morey, 2002, p. 28-29), and zero values, or "corner solutions" in an incomplete demand system (von Haefen, 2010). In A.1 the Willig (1976) conditions for approximating EV by VCS are shown easily met for all groups with positive consumption, $Q_i^0 > 0$. For such cases the total Willig (1976) upper bound on error is a few tenths of one percent. As for those cases where $Q_i^0 = 0$, any VCS_i must be positive, and thus by (7), conservative in its estimate of improvement in EV_i.

Aside from estimation issues, incentives give another reason to prefer VCS – its simplicity. The incentive scheme developed here requires public and transparent pricing. Here *transparency* means a formula that can be understood. If most professional economists still use VCS in applied work,[5] we should not expect the broad public to understand the more complex exact measures.

V.1 No Negotiation as a Sub-Game Perfect Strategy

To see the change in producer surplus ($d\pi_i$ from (4)) over VCS ($d\theta_i$ from (6)), we have, if $Q^*_i > 0$:

$$|d\pi_i|/|d\theta_i| = |dP_i|[Q^*_i - \beta(P^*_i - \mu)Pop_i\,]/(|dP_i|Q^*_i)$$

$$= [Q^*_i - \beta(P^*_i - \mu)Pop_i\,]/Q^*_i \equiv \lambda_i > 0 \qquad (8)$$

We see that the ratio of $|d\pi_i|$ to $|d\theta_i|$ is a constant of proportionality λ_i fixed by Country i's identifying variables. These determine P^*_i and Q^*_i, independently of any price change dP_i.[6]

If it is profitable for the company to sell Q to i, i.e., $Q^*_i > 0$, then the profit margin must be positive $(P^*_i - \mu) > 0$. Thus the term within the square brackets of (8) must be positive, and the value of the ratio less than 1. This implies that the fall in π_i cannot be as great as the rise in θ_i:

$$0 < \lambda_i \equiv |d\pi_i\,| / |d\theta_i| < 1. \qquad (8a)$$

From the definition of τ_i in (5), and dividing by λ_i, (8) yields

$$|\Delta\tilde{\pi}_i| = \tau_i\,|\Delta\pi_i| \Rightarrow |\Delta\tilde{\pi}_i|/\,\lambda_i = \tau_i\,|\Delta\pi_i|/\,\lambda_i \Rightarrow |\Delta\tilde{\theta}_i| = \tau_i\,\Delta\theta_i > 0, \qquad (9)$$

where $|\Delta\tilde{\theta}_i|$ is the loss of consumer surplus to Country i implied by its threatened curtailment of

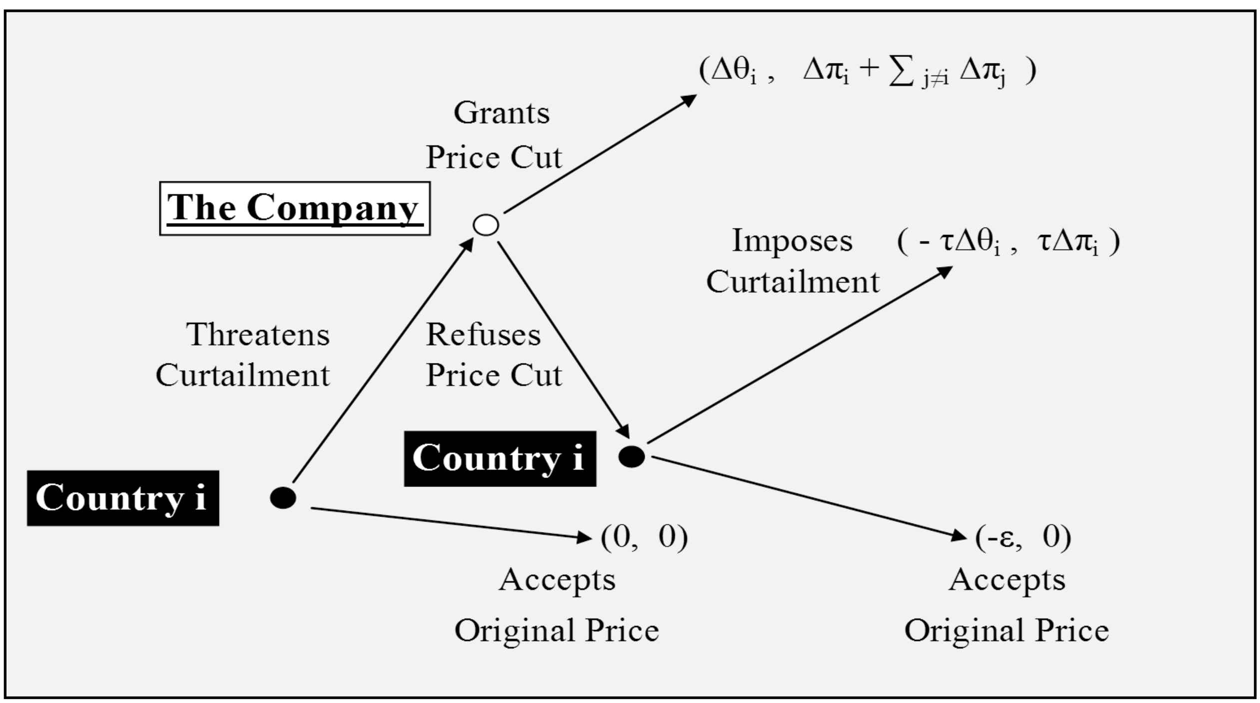
5 While derivation of the exact measures EV and CV has been known at least since Hausman (1981), the over-whelming bulk of applied work continues to use VCS. This is easily confirmed by key-word searches in Google Scholar, even when limited to 'Peer-Reviewed Journals.' See Stodder (2013) and the World Bank reports cited by Peskin (2006).

6 One should note that it is the linearity of Consumer Surplus that allows this constant proportionality with linear Producer Surplus, thus greatly simplifying the analysis. The Appendix shows that this approximation is usually close.

Company profits, $|\Delta\tilde{\pi}_i|$. Thus $|\Delta\tilde{\theta}_i|$ is the Country's damage to *itself* in carrying out its threat. Note that while the Country's hoped-for gain in consumer surplus, $\Delta\theta_i$, is positive, all terms in (9) within absolute value markers are *negative*. Thus (9) shows that any threatened cut in profits large enough to make a price cut for the Company rational (the first equation), implies a proportional *reversal* of the hoped-for consumer surplus gains to the Country itself (the final equation). A threat big enough to be effective, in other words, is too big to be credible. (In the next section we ask what happens if a Country's decision makers do not have maximization of consumer surplus as their aim.)

To examine how these incentives play out, consider Figure 1 below. Under the strong assumption of common knowledge on payoffs and rationality – incentive compatibility is trivial. (We will soon relax these assumptions.) Starting from the final possible decision node, Country i can be forced to pay a small penalty, – ε, for the delay caused by challenging the original price. Under common knowledge, i's threat to cut purchases is non-credible: the cost, $-\tau_i\,\Delta\theta_i$, is much worse than -ε.

Figure 1: Choices and Incentives under MFC Price-Discrimination



Moving back to the prior decision, the Company will reject the price cut. Its acceptance would impose a payoff of $\Delta\pi_i + \sum_{j\neq i} \Delta\pi_j$ (with all terms negative), while its refusal – since the Country will never impose curtailment – has a cost of zero. The final step of induction brings us back to Country i's original choice. Faced with the inevitability of its own capitulation and the penalty $-\varepsilon$, Country i's best choice is to not make the threat. Accepting the original price is a sub-game perfect equilibrium, and the MFCPD is incentive compatible.

V.2 <u>Relaxing the Assumption of Common Knowledge</u>

Relaxing the strong assumption of common knowledge, we can show that the MFCPD is robust to a Country maximizing its expected value. As previously shown, Country i's threat must be large in absolute value to motivate the Company. By comparing the payoffs to the Company on the paths to *granting* versus *refusing* the price cut in Figure 1, we see that for the former to be favored, we need:

$$|\Delta\pi_i| + \sum_{j\neq i} |\Delta\pi_j| < |\Delta\tilde{\pi}_i| = \tau_i\, |\Delta\pi_i|,$$

a rewriting of (5) and (5a). (Note that all terms within absolute value signs are negative.) As noted, the size of these values implies that the threat $\Delta\tilde{\pi}_i$ must be large, $|\Delta\tilde{\pi}_i| = \tau_i|\Delta\pi_i|$, where $\tau_i > 2.63$ for the United States in our illustration. If a coalition of buyers is possible, it would need more market power than the United States to achieve a lower threat ratio τ_i.

Let us assume that Country i believes it might successfully threaten the Company. If the probability of the Company agreeing to the price cut is p, then a positive expected return to Country i means that it should make the threat. Say there is a p chance of i receiving $\Delta\theta_i > 0$ (its return if the price cut is granted), and a (1-p) chance of getting $-\tau_i\,\Delta\theta_i$ (its cost if the threat is rejected, and it needs to make the threatened curtailment). A positive expected return on the threat can be written:

$$p\Delta\theta_i + (1-p)(-\tau_i\,\Delta\theta_i) = [p - (1-p)\,\tau_i]\Delta\theta_i > 0 \quad \Rightarrow p > (1-p)\,\tau_i. \tag{10}$$

In words, if Country i's threat is worth making, then the probability of the Company acceding to its threat must be greater than the probability of its *not* acceding times the required threat multiplier. Recalling that in our example τ_i is greater than 2.63 for the US, (10) implies a value of $p > 0.7245$. For a country with a market smaller than the US, p would have to be larger still. Thus a small Country will not make such a threat unless it believes the Company is almost certain to yield to it.

This formalizes a one-period game, but raises the question of whether it might be worthwhile for a Country to take a temporary loss for a longer-term gain. Thus the above one period result may be reversed if the Country's leadership has a rate of time preference much lower than the Company's. This is unlikely to be true in financial terms, but our model does not address political motivations. These might lead a Country's leadership to a confrontation that would not seem financially rational.

VI. Threat Multipliers and the Fineness of Price Discrimination

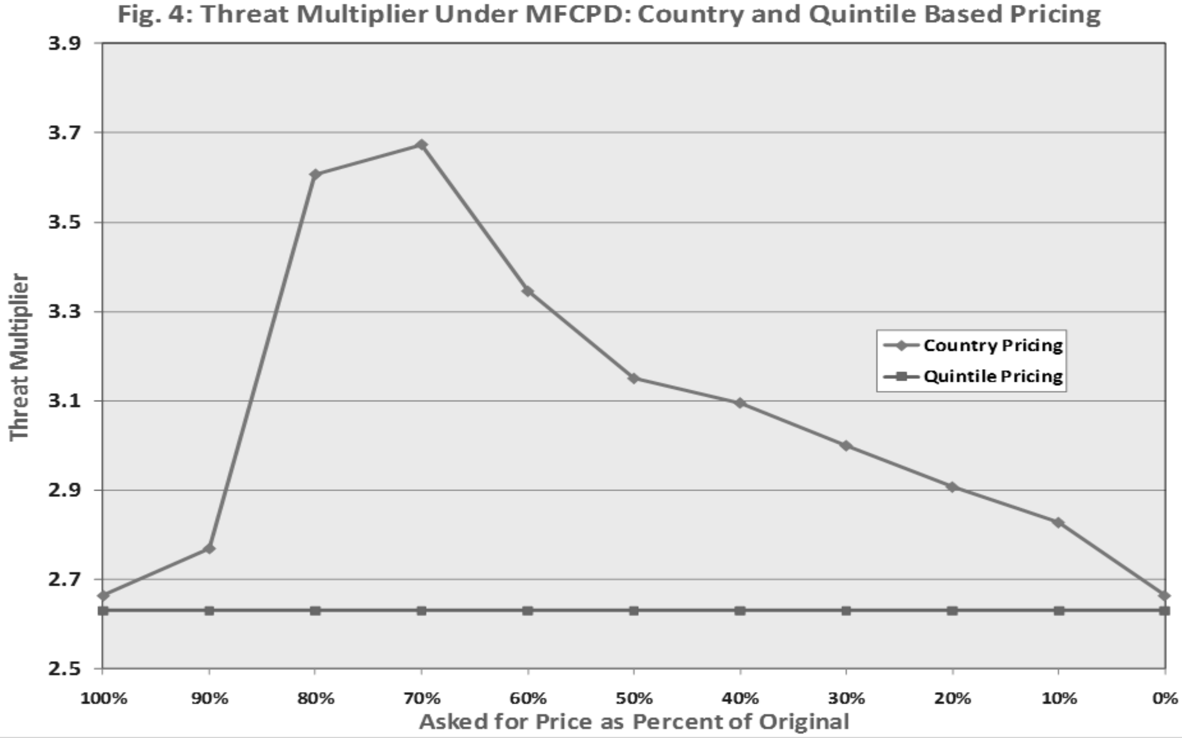
We can show that the threat multiplier τ_i becomes *more stable* under Country discrimination, since there are fewer zero-consumption Quintiles. And with the most finely-grained, Quintile-based discrimination, the threat multiplier is perfectly stable. There are no "corner solutions" (even the poorest Quintiles buy the product) so the threat multiplier of a linear discrimination rule will itself be linear. The following proposition is demonstrated in Appendix A.2.:

> **Proposition**: If price discrimination in a linear demand system is sufficiently fine, the threat multiplier will not change as greater price discounting is demanded.
>
> **First Corollary:** For a less than maximally fine level of discrimination, as greater price discounting is demanded, the threat multiplier will begin to rise.
>
> **Second Corollary:** At any fineness of price discrimination that is less than maximal, as greater price discounting is asked for, the threat multiplier for a linear demand system will converge to a stable point, that of the finest possible level of discrimination.

Figure 2 below shows that Quintile-based pricing is perfectly stable. The rising prices of the first corollary are also shown for Country pricing. And as the second corollary claims, deeper price cuts mean that more groups get positive consumption, so that even 'grosser' forms of price discrimination converge to a stable threat multiplier. Lower prices for the poorest consumers wash out the corner-solutions and their resulting non-linearity. Note, however, that the perfect stability shown in Figure 2 is by construction: price discrimination by Quintile is "perfect" only in the sense that it is the maximum granularity allowed by our data. But no product is consumed by everyone, so a finer level of discrimination is always conceivable.

The Propc **Fig. 2:** ates that with less-than-perfect discrimination, the threat multiplier must increase as greater reductions in P are demanded. Note that this enhances the incentive compatibility of MFCPD. As the equations in (9) show, a larger threat multiplier means that Country i must reduce its own purchases, and thus its own welfare, by the same larger multiplier – making its threat to do so increasingly less credible. Large pharmaceutical companies and the US government currently practice income-based price discrimination between income groups *within* the US.[7] This more finely gauged discrimination could be practiced in many countries – although some cooperation with the country's government is probably required: for example, to verify household income records.

Fig. 4: Threat Multiplier Under MFCPD: Country and Quintile Based Pricing



[7] Two recent examples are "Pfizer Pfriends" and Merck's "Prescription Discount Program." See corporate websites for details: http://www.pfizerhelpfulanswers.com/pages/Find/findall.aspx, http://www.merck.com/merckhelps/.

VII. Price Discrimination and Income Distribution: A Numerical Example

To describe our numerical example, let us assume the Company is selling a pharmaceutical product and that we have estimated the demand for our product in different countries. Let our estimates be based on income, and calculated at $\alpha = 1.0$, $\gamma = 0.0002$, $\beta = 1.0$, and $\mu = 0.10$. From (2b) we have

$$P^*_{ji} = (\alpha + \gamma Y_{ji} + \mu\beta)/2\beta \quad = \quad [1 + 0.0002(Y_{ji}) + 0.1]/2 \quad = \quad 0.55 + 0.0001(Y_{ji}), \tag{11}$$

where Y_{ji} is the per-capita income of Quintile i within Country j, and P^*_{ji} the optimal price to this Quintile. We will use (11) to illustrate World pricing, using IMF figures for Population and GDP per capita in 2005 in then-current US Dollars,[8] and World Bank data on (household) income distribution for around that same year.[9] There are 119 countries for which all these data were available. We will apply price formula (11) at three different levels of discrimination:

a) No price discrimination: no subscripts; one World-wide monopoly price;
b) Country-based pricing: no subscript j; a price for each Country i, 119 separate prices;
c) Quintile-based pricing: subscripts i and j; a price for each Country i and each income *Quintile* (j = 1, 2, 3, 4, 5), for 5*119 = 595 prices in all.

Case c) provides an interesting limiting case. Appendix A.2 shows that a finer degree of price discrimination brings greater producer surplus, since it can profit whenever consumers' reservation price, $\bar{P}_i > \mu$. This will often bring greater consumer surplus, since it eliminates 'corner solutions.'

In Table 1 below, we note that total pharmaceutical expenditures range from 1.5 to 0.8 percent of GDP. As will be seen, the percent spent on our single price discriminated good is of this order for most countries and income levels in our example. In no case do pharmaceutical expenditures come to more than 1.5 percent of GDP. We will see repeated another pattern shown in the last column of

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8 International Monetary Fund, World Economic Outlook Database, September 2006 Edition, http://www.imf.org/external/pubs/ft/weo/2006/02/data/index.aspx.

9 World Bank, World Development Indictors 2006, http://www.worldbank.org/data. While GDP and population data from the IMF are for the 2005, the income distribution *percentages* from the World Bank are only for the most recent year available. (We do not use distributional data later than 1995). Income distributions do not tend to change rapidly, however (Atkinson, 1983), so this is a reasonable first estimate. Distributional data are for *households*, not individuals. We are thus treating all individuals within a single household as having the same income – as is reasonable for access to medical care.

Table 1: poorer countries spend a smaller portion of their incomes on pharmaceuticals. This makes it appear that pharmaceuticals are 'superior' goods, with income elasticity greater than 1. Most estimates, however, are much lower; a recent cross-national estimate of income elasticity is between 0.15 and 0.6 (Danzon *et. al.,* 2011).

Table 1: World Expenditures on Health and Pharmaceuticals, 2000

Income Group *(1)*	% of Total Expenditure on Pharma	Pharma as % of all Health Expenditure	% of GDP Expended on Health *(2)*	% of GDP Expended on Pharma *(3)*
High Income	78.7	13.8	10.8	1.5
Middle Income	18.8	24.8	6.0	1.5
Low Income	2.4	19.2	4.4	0.8

Notes*: (1) World Bank Groupings, July 2000. (2) Data from 2001. (3) Product of previous 2 columns.*
Sources: World Bank Group, Disease Control in Developing Countries, 2nd Ed., World Bank (2006). Jamison (chap. 1), Foster *et. al.* (chap. 72).

With a single World monopoly price, the profit maximizing price is $4.72 US (in 2005 US Dollars). It is important to note that this profit maximizing price P* *cannot* be derived simply from equation (2b). This formula can only be directly applied to world GDP if each Quintile in each Country consumes a positive quantity of the product. Most Quintiles, and indeed most countries, consume nothing at the profit-maximizing single price, making demand highly non-linear. With average world per capita GDP of $7,217 and a population of almost six billion, (2b) implies an apparent World monopoly price of $1.27. When this lower price is applied, producer surplus is only $7,016 million – less than half the true maximum shown in Table 2 below. Finding the profit-maximizing monopoly price requires non-linear optimization algorithms such as Evolver ™, used here.

Table 2a. Single World Monopoly Price vs. Country and Quintile Based Discrimination*

Price Regime	Population	GDP per capita	Average Price	Total Quantity	% GDP Expended	Producer Surplus	Consumer Surplus	Total Surplus
One World Monopoly Price	5,988	$7,217	$4.72	3,506	0.04%	$16,181	$15,807	$31,988
Price for Each Country	" "	" "	$1.68	6,609	0.03%	$18,943	$15,787	$34,730
Price for Each Quintile	" "	" "	$1.56	7,016	0.05%	$22,938	$11,469	$34,408

** Population, Quantity, and Surplus Figures are in units of one million.*
Note: GDP % Spent = (Price)(Quantity)/[(Population)(GDPpc)]

Producer surplus rises with finer degrees of price discrimination in Table 2a, as it must. Consumer surplus, on the other hand, while only slightly lowered by the move from World to Country pricing, falls sharply in the move from Country to Quintile pricing. We will examine the distributional effects of these changes in more detail.

Moving to finer, 'more perfect' forms of discrimination – first by Country and then by Quintile – Table 2a shows a necessary condition for welfare improvement: increasing quantity (Schmalense, 1981). But this is not a sufficient condition. Total surplus is almost as high (falling by less than one percent), in moving from Country to Quintile-based pricing, but this is because the increase in producer surplus has been offset by a *decrease* in consumer surplus.

Thus, unless our social welfare function is weighted towards improvements to the poor, i.e., with at least a mild degree of 'inequality aversion' (Atkinson, 1970; Okun, 1975) welfare would be seen as declining. Table 2.b shows the basic distributional data.

Table 2b. **VCS Change from Finer Discrimination, All Countries' Quintiles**

Discrimination Basis Moves from	First Quintiles	Second Quintiles	Third Quintiles	Fourth Quintiles	Fifth Quintiles	Total
World to Country	$76	$104	$8	($114)	($93)	($20)
Country to Quintile	$339	$618	$723	$281	($6,280)	($4,319)
World to Quintile	$415	$722	$731	$167	($6,373)	($4,339)

All figures are in units of one million; negative figures in parentheses.

Note that the last row in Table 2b is the sum of the other two. In our numeric example, only 32 of the 119 countries can buy anything at the single World monopoly price. Even in most rich countries, the lowest income groups cannot afford the product. Since most of the world cannot afford life-saving drugs at current world prices (DuMoulin, 2001), this is realistic. The 32 countries that *can* purchase at the World monopoly price are listed below, with number of consuming Quintiles in parentheses:

Table 3a: 32 Countries Able to Buy Good at Single World Monopoly Price: Number of Countries, C (and Quintiles, Q) Purchasing

5 C (5Q)	GDPpc	12 C (Top 4 Q)	GDPpc	12 C, 4 Q(*cont.*)	GDPpc
Denmark	$47,984	Australia	$34,740	Germany	$33,854
Japan	$35,757	Austria	$37,117	Ireland	$48,604
Luxembourg	$80,288	Belgium	$35,712	Netherlands	$38,618
Norway	$64,193	Canada	$35,133	Sweden	$39,694
Switzerland	$50,532	Finland	$37,504	United Kingdom	$37,023
		France	$33,918	United States	$42,000
Avg GDPpc	**$55,751**			**Avg GDPpc**	**$35,687**
5 C (Top 3 Q)	**GDPpc**	**5 C (Top 2 Q)**	**GDPpc**	**5 C (Top 1 Q)**	**GDPpc**
Hong Kong	$25,493	Greece	$20,327	Chile	$ 7,124
Italy	$30,200	Israel	$19,248	Czech Republic	$12,152
New Zealand	$26,464	Korea	$16,308	Estonia	$ 9,727
Singapore	$26,836	Portugal	$17,456	Hungary	$10,814
Spain	$27,226	Slovenia	$16,986	Mexico	$ 7,298
Avg GDPpc	**$27,244**	**Avg GDPpc**	**$18,065**	**Avg GDPpc**	**$ 9,423**

In moving to Country-based pricing, there is a marked increase in the number of Quintiles that can purchase the good. In Table 3a, under single World pricing, only 32 countries and a total of 103 Quintiles can buy the drug. Under Country pricing, by contrast, only a total of 25 Quintiles in 22 countries cannot buy it; see Table 3b below. And there are 9 rich countries that find no Quintile improved by the move to Country pricing. (Note that some small wealthy countries such as Qatar and Liechtenstein were not included in the World Bank Income Distribution Data Set.) Under Quintile-based pricing, by contrast, no country's poor were unable to buy the good in our example. This is a consequence of our modeled drug having a very low marginal cost. As long as a consumer is able to pay anything above this, it benefits the producer to sell.

Table 3b: Lower Quintiles Unable to Buy Good under Country-based Discrimination

19 Countries where 1st Quintile (Poorest 20%) Cannot Buy				3 Countries where 1st and 2nd Quintiles (Poorest 40%) Cannot Buy
Australia	Denmark	Israel	Portugal	
Austria	France	Italy	Spain	Hong Kong
Belgium	Germany	Luxembourg	Switzerland	Singapore
Canada	Greece	Netherlands	United Kingdom	United States
Chile	Ireland	New Zealand		

Table 3c: Nine Wealthy Countries: No Quintile Improved by Move from World to Country-Based Pricing

Austria	Norway
Denmark	Switzerland
Ireland	United Kingdom
Luxembourg	United States
Netherlands	

On the evidence of Tables 3b and 3c, it is not surprising that political opinion in richer countries is hostile to the standard 'Country-based' form of price discrimination. Since it makes prices higher for *all* consumers in these countries, Consumer Surplus must fall for those with any prior consumption. This is in stark contrast to the effect of the change for most countries. Figure 3 below shows that, except for the nine rich countries of Table 3c, the top four or five Quintiles of all others benefit from the move to Country-based pricing. (If just the top four Quintiles benefit, then the lowest is not affected: it could not purchase the drug under either price regime.)[10] By increasing access for a large global majority, the move from World to Country-based pricing shown in Figure 3 implies welfare gains under even a modestly egalitarian social welfare function (Atkinson, 1970; Okun 1975). Yet Table 3b shows that it may be difficult to reach a global consensus on this issue.

It was seen in Table 2a that the *quantity* gain in moving from a single World monopoly price to Country-based price discrimination is large – nearly doubling the total provided. Schmalensee (1981) establishes that such an increase in quantity is a *necessary* condition for an increase in consumer surplus when moving from a single price to price discrimination. For linear demand curves, Schmalensee notes (1981, *fn*. 4) that this necessary condition is equivalent to some consumers getting zero quantities under the single price regime, one that is above their reservation price. Table 3a shows this is true for the great majority of countries. DuMoulin (2001) also finds widespread zero-consumption in his simulation of pharmaceutical price discrimination.[11]

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[10] Individual countries' governments could undertake further action to reduce these remaining inequities; see Section VII below.

[11] After calculating the profit-maximizing price for each income Quintile within each Country, DuMoulin (2001) shows how one can 'target' the price of that Quintile giving the highest profits. This will not be the profit-maximizing

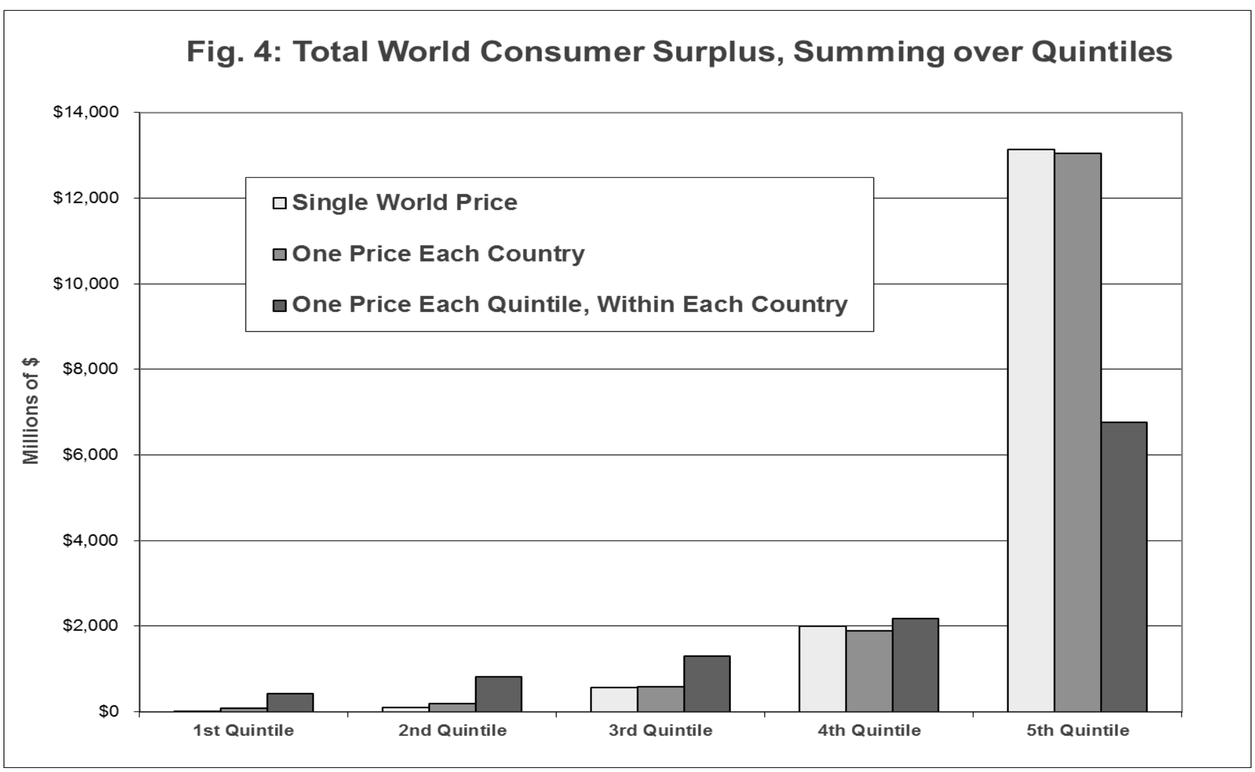
Figure 3 above shows how moving from World to Country pricing, Consumer Surplus summed over all countries increases for all Quintiles except the fourth and fifth – and even these are diminished only slightly. Since Table 2a shows total surplus as increasing (through greater producer surplus), the change from a World monopoly price to Country-based pricing must be efficiency improving.

The move from Country-based to Quintile-based pricing might be more controversial, even though the great majority is benefited, especially the poor. Figure 4 shows that there are overall income gains for the first four Quintiles of all countries. The fall in surplus to the fifth Quintile, however, is large enough to mean a fall in total Consumer Surplus.

Total surplus (to both consumers and producer) declines by less than 1 percent in the move from Country to Quintile pricing, as was shown in Table 2a. So if there is willingness to tradeoff a small amount of efficiency for greater equality (Okun, 1975) this more 'discriminating' discrimination could be welfare improving. One might do still better with further discrimination, via government intervention. This is a topic we leave for our concluding section.

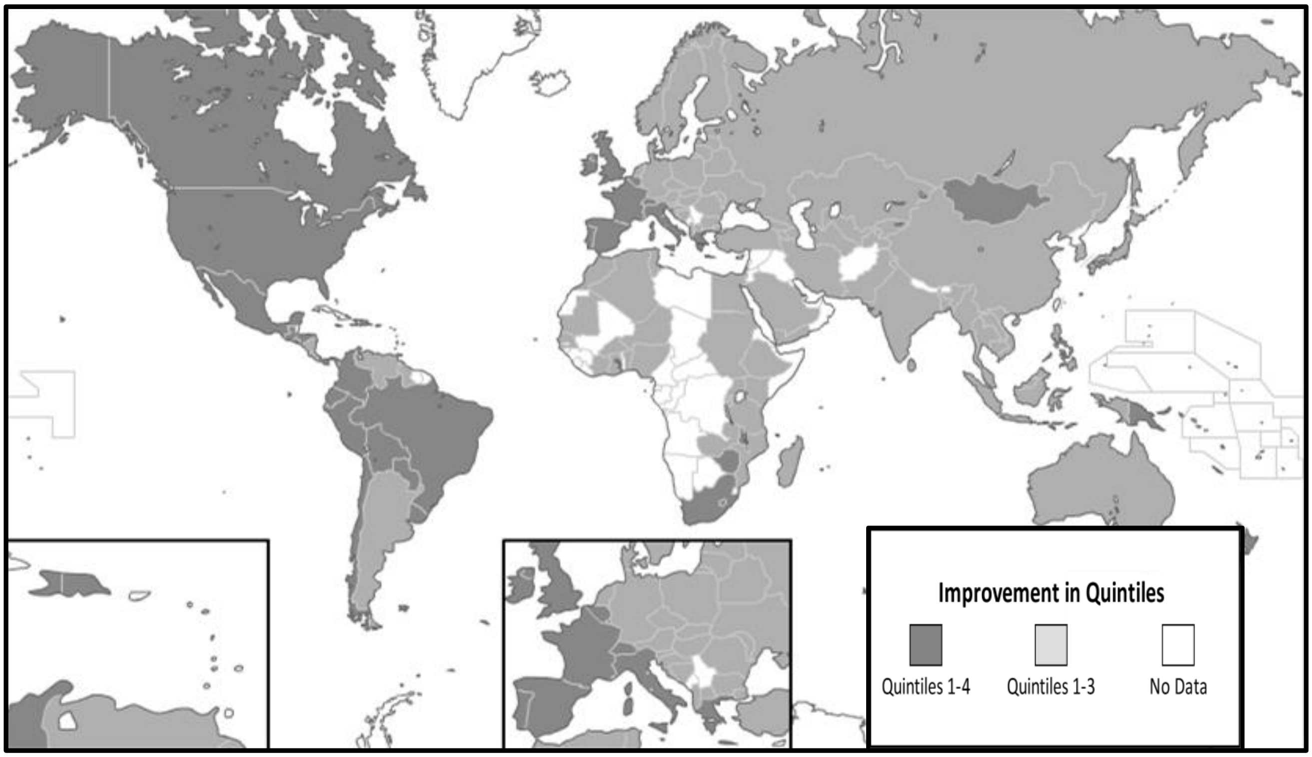
price for the Country as a whole. It is usually a good approximation, however, and has the benefit of computational simplicity. Our calculations, by contrast, are highly non-linear: there are a large number of non-negativity constraints.

Figure 3: Countries with Quintiles Improved by the Move from World to Country-based Pricing



Despite this fall in total consumer surplus in moving from Country to Quintile-based pricing, it is worth emphasizing that the vast majority is benefited, in every country. Fig. 5 below shows that the lowest 3 or 4 Quintiles are improved thereby, in every country for which we have distributional data.

Figure 5: Change from Country to Quintile Based Prices: Improvement for Lowest 3 or 4 Quintiles



There is often interest in further distributional details. The three large North American countries are shown in Table 4a and 4b below. These replicate the global pattern of surplus distribution: producer surplus increases with increasingly fine discrimination, while overall consumer surplus declines. At the same time, however, most Quintiles benefit. As in the global pattern, the change towards greater equality is marked by a fall in total consumer surplus. In moving from a single World-price to Country-based pricing, every Quintile in Canada and Mexico gets more consumer surplus – while every Quintile in the US gets nothing or less. Overall consumer surplus is seen to fall. In moving from Country to Quintile-based pricing, by contrast, each of the first four Quintiles gains in all three countries, while each fifth Quintile loses. Losses to the fifth Quintiles outweigh gains to all others.

Table 4a: Pricing Schemes and Quantities Consumed, 3 North American Countries

Country and Quintile	Per Capita Income	World Price	Country Prices	Quintile Prices	Quantity @ World Price	Quantity @ Country Prices	Quantity @ Quintile Prices
Canada1	$12,656.6	**$4.72**	**$4.63**	$1.82	-	-	11.1
Canada2	$22,354.3	" "	" "	$2.79	4.9	5.5	17.3
Canada3	$30,179.7	" "	" "	$3.57	15.0	15.5	22.4
Canada4	$40,322.1	" "	" "	$4.58	28.0	28.6	28.9
Canada5	$70,154.7	" "	" "	$7.57	66.5	67.1	48.1
All Canada	**$35,133.5**				**114.4**	**116.7**	**127.7**
Mexico1	$1,571.2	**$4.72**	**$1.28**	$0.71	-	0.7	12.8
Mexico2	$3,024.6	" "	" "	$0.85	-	6.8	15.8
Mexico3	$4,611.6	" "	" "	$1.01	-	13.5	19.2
Mexico4	$7,185.9	" "	" "	$1.27	-	24.4	24.6
Mexico5	$20,094.4	" "	" "	$2.56	6.4	78.7	51.8
All Mexico	**$7,297.6**				**6.4**	**124.2**	**124.2**
United States1	$11,415.8	**$4.72**	**$6.42**	$1.69	-	-	94.4
United States2	$22,431.5	" "	" "	$2.79	45.7	-	159.7
United States3	$32,887.3	" "	" "	$3.84	169.8	68.5	221.8
United States4	$47,053.1	" "	" "	$5.26	337.8	236.6	305.8
United States5	$96,214.5	" "	" "	$10.17	921.0	819.8	597.4
All United States	**$42,000.4**				**1,474.3**	**1,124.9**	**1,379.0**
				All 3 Countries	**1,595.1**	**1,365.8**	**1,631.0**

Table 4b: Pricing Schemes and Changes in Producer Surplus (ΔPS), Consumer Surplus (ΔCS), and Total Surplus (ΔTS) in 3 North American Countries

Country	from World to Country Prices			from Country to Quintile Prices			from World to Quintile Prices		
and Quintile	ΔPS	ΔCS	ΔTS	ΔPS	ΔCS	ΔTS	ΔPS	ΔCS	ΔTS
Canada1	$0.0	$0.0	$0.0	$19.0	$9.5	$28.5	$19.0	$9.5	$28.5
Canada2	$2.2	$0.5	$2.6	$21.8	$20.9	$42.8	$24.0	$21.4	$45.4
Canada3	$1.3	$1.4	$2.6	$7.2	$20.0	$27.2	$8.5	$21.4	$29.9
Canada4	$0.1	$2.5	$2.6	$0.0	$1.2	$1.3	$0.1	$3.8	$3.9
Canada5	($3.4)	$6.0	$2.6	$55.7	($169.4)	($113.6)	$52.4	($163.4)	($111.0)
All Canada	**$0.2**	**$10.4**	**$10.6**	**$103.7**	**($117.7)**	**($13.9)**	**$104.0**	**($107.3)**	**($3.3)**
Mexico1	$0.9	$0.0	$0.9	$6.9	$3.9	$10.8	$7.8	$3.9	$11.6
Mexico2	$8.1	$1.1	$9.2	$3.8	$4.8	$8.7	$11.9	$6.0	$17.9
Mexico3	$16.0	$4.3	$20.3	$1.5	$4.4	$5.9	$17.5	$8.7	$26.2
Mexico4	$28.8	$14.1	$42.9	$0.0	$0.3	$0.3	$28.8	$14.4	$43.1
Mexico5	$63.4	$146.3	$209.6	$34.5	($83.5)	($49.0)	$97.9	$62.7	$160.6
All Mexico	**$117.0**	**$165.8**	**$282.9**	**$46.8**	**($70.1)**	**($23.4)**	**$163.8**	**$95.7**	**$259.5**
United States1	$0.0	$0.0	$0.0	$150.2	$75.1	$225.4	$150.2	$75.1	$225.4
United States2	($211.1)	($17.6)	($228.7)	$430.2	$215.1	$645.3	$219.1	$197.5	$416.6
United States3	($350.2)	($203.4)	($553.6)	$395.8	$374.9	$770.7	$45.6	$171.6	$217.1
United States4	($63.4)	($490.2)	($553.6)	$80.7	$316.3	$397.0	$17.3	($173.8)	($156.5)
United States5	$931.9	($1,485.5)	($553.6)	$833.9	($2,656.9)	($1,822.9)	$1,765.8	($4,142.3)	($2,376.5)
All United States	**$307.2**	**($2,196.6)**	**($1,889.4)**	**$1,890.8**	**($1,675.4)**	**$215.5**	**$2,198.0**	**($3,872.0)**	**($1,674.0)**
All 3 Countries	**$424.4**	**($2,020.4)**	**($1,596.0)**	**$2,041.3**	**($1,863.2)**	**$178.2**	**$2,465.8**	**($3,883.6)**	**($1,417.8)**

*___*All Surplus Figures are in units of one million.*

VIII. Conclusions and Extensions

The device of Most Favored Customer Price Discrimination (MFCPD) appears to solve the major incentive problem attending Price Discrimination – the power of large customers to negotiate better terms and thus undermine the pricing structure. By making discrimination transparent – based on a published formula and historic GDP figures which the customer can do nothing to change – the company makes a contractual commitment to hold everyone to the same *form* of discrimination.

Price discrimination necessarily benefits the seller. To increase total consumer surplus, however, an increased quantity sold is a necessary condition (Schmalensee, 1981; Varian, 1985). DuMoulin (2001) notes that this condition is met in for pharmaceuticals: most income groups have no access under a single World price. Similarly, our numeric example shows large benefits for a majority of global population in moving from a single World price to Country-based prices, and from Country to Quintile-based prices. Overall quantity also increases slightly in the move from Country to Quintile-based discrimination. But the necessary condition for an increase in total consumer surplus is not sufficient, and aggregate surplus falls – from losses to top Quintiles in the richest countries.

Like most models of price discrimination, our model is driven by simple profit maximization. Any practical application, however, must confront political pressures. The opposition of higher income groups and countries will often limit the degree of discrimination that can be achieved, and the "optimized" formula may have to incorporate those constraints.

Whatever the formula for price discrimination used by a corporate seller, there is no reason for any government to accept this as the last word. Higher or lower degrees of discrimination can be achieved domestically. These could range from a different price for each household, to a single price for all. And with the detailed records available to many governments, there is no reason to limit the basis of discrimination to income – health, age, education, and work history are further reasonable bases.

Further discrimination by and within an individual country does not violate that country's MFCPD contract with the Company. Nor need it conflict with Company interests; by building greater support for the program, it may support those interests. Also, there is nothing in our model that limits it to pharmaceuticals or to international trade. It may be applied to any market where resale or reference pricing inhibit price discrimination.

APPENDIX

A.1 Error Bounds on Variation in Consumer Surplus

The Willig (1976) error bounds for a normal good Q are

$$0 \leq \underline{\eta}|VCS|/2Y \leq (EV - VCS)/|VCS| \leq \bar{\eta}|VCS|/2Y, \tag{A1}$$

where $\underline{\eta}$ and $\bar{\eta}$ are the smallest and largest positive values of the income elasticity of demand over the price interval, EV and VCS are Equivalent Variation and Variation in Consumer Surplus, respectively, and Y is income. Necessary conditions for applying (A1) are that there has been only one price change, that the right hand side is less than 5 percent, and that the ratio of absolute VCS to income, |VCS|/Y, should be less than 90 percent. As for this last condition, in our example the highest value for $|VCS_{ij}|/Y_{ij}$, for the poorest Quintile of Burundi, is less than four-tenths of one percent. More generally, recall from World Bank survey data (Table 1) that the average portion of GDP spent on all pharmaceuticals averages less than 2 percent of GDP, in both developed and developing countries. Thus, the 90 percent constraint is not likely to be binding here.

The right hand side of (A1) will be shown to usually be quite small, making it the only term of interest; we can simplify (A1) to

$$0 \leq (EV - VCS)/|VCS| \leq \bar{\eta}|VCS|/2Y.$$

Thus the only condition of concern is that $\bar{\eta}|VCS|/2Y$ should be less than 0.05. Recall that the largest estimate of income elasticity for health care in a recent study (Danzon *et. al.,* 2011) was 0.6. Multiplying this by the World Bank estimate of |VCS|/2Y at 2 percent, we get $\bar{\eta}|VCS|/2Y = 0.012$, considerably less than 0.05. In our own illustrative data, as long as Q > 0, this Willig upper bound was just 0.006 – six tenths of one percent.

For a consumer not consuming anything at current prices, income elasticity is likely to be zero as well. Note, however, that as price rises to the reservation price or 'choke point' $\bar{P}_i$ (the minimum price at which Q = 0), the elasticity of income for a normal good must approach infinity. Thus the Willig bounds do not apply if consumption goes from zero to a positive value. However, as noted in von Haefen (2010), this "corner solution" in an incomplete demand system also means that EV and CV cannot be consistently estimated. So in such cases, VCS is at least consistently estimable.

These cases where Q_i goes from null to positive make up a substantial part of the total VCS in our example. Under the three pricing regimes of Table 2a, we can total up the VCS for all these cases. Moving to finer grades of price discrimination, the impact on VCS is negative – losses to rich countries outweigh gains to the poor, as we have seen. Including these null-to-positive changes increases total VCS pricing by 99, 25, and 9 percent, in the changeover from World to Country, Country to Quintile, and World to Quintile pricing, respectively. Recall that positive VCS estimates of EV are conservative, by (7). Thus the welfare gains from finer price discrimination – through the increased consumption of poorer groups – will always be underestimated.

A.2 <u>Proof of the Proposition</u>

Definition - *<u>Finer</u> Discrimination*: A level of price discrimination j is *finer* than level k when each group of k can be further divided into s *sub-groups,* where s is an integer ≥ 2 and *j = s*k.*

Proposition: If price discrimination in a linear demand system is sufficiently fine, then the threat multiplier will not change as lower prices are demanded.

Proof: Using j as both a level and a subscript, assume that j = (1, …, N) is the finest level of discrimination possible. As long as the profit-maximizing price for group j is greater than marginal cost, $P^*_j > \mu$, and lower than j's reservation price $\bar{P}_j$, then this implies that Q^*_j and $\pi^*_j > 0$, $\forall$ j. Let Country i be included in the set (j = 1, .., i,.., N). Then using (3a), (3b) and (5a), we have:

$$\tau_i \equiv \Delta\tilde{\pi}_i/\Delta\pi_i > (\textstyle\sum_j \Delta\pi_j)/\Delta\pi_i$$

$$= \textstyle\sum_j \Delta P_j\,[Q^*_j - \beta(P^*_j - \mu)Pop_j\,] \,/\, \Delta P_i\,[Q^*_i - \beta(P^*_i - \mu)Pop_i\,]$$

$$= \textstyle\sum_j (\Delta\gamma Y_j/2\beta)\,[Q^*_j - \beta(P^*_j - \mu)Pop_j\,] \,/\, (\Delta\gamma Y_i/2\beta)\,[Q^*_i - \beta(P^*_i - \mu)Pop_i\,]$$

$$= \textstyle\sum_j (Y_j/2\beta)\,[Q^*_j - \beta(P^*_j - \mu)Pop_j\,] \,/\, (Y_i/2\beta)\,[Q^*_i - \beta(P^*_i - \mu)Pop_i\,] = c_i,$$

where the ΔP terms are substituted out by (2d). Note that if these $\Delta P < 0$ terms are changed via a MFC clause, this implies the same $\Delta\gamma$ for *every* MFC. Thus the ratio $\sum_j \Delta P_j/\Delta P_i$ cannot change. All terms in the last line are given by the original data, estimation, or optimization. Thus c_i is a constant regardless of ΔP_i or $\sum_j \Delta P_j$. Thus for fine enough discrimination, i's threat multiplier is stable.

First Corollary: For a less than maximally fine level of discrimination, as greater price discounting is demanded, the threat multiplier must begin to rise.

Proof: Let us now take a less fine (*grosser*) form of discrimination, combining groups of j = s*k into grosser and fewer sets k. If profit-maximizing prices at this grosser discrimination at P^*_k yield lower profits than at P^*_j, then some of these k groups, subscripted k2, must show $\Delta\pi_{k2} = 0$. Then the lower limit which defines the threat multiplier τ_i can be decomposed:

$$(\sum_k \Delta\pi_k)/\Delta\pi_i = \{\sum_{k1}\Delta\pi_{k1} + \sum_{k2}\Delta\pi_{k2}\}/\Delta\pi_i$$

$$= \{\sum_{k1}\Delta P_{k1}[Q^*_{k1} - \beta(P^*_{k1} - \mu)Pop_{k'}] + \sum_{k2}\Delta P_{k2}[Q^*_{k2} - \beta(P^*_{k2} - \mu)Pop_{k2}]\}/\Delta P_i[Q^*_i - \beta(P^*_i - \mu)Pop_i],$$

where the sum of the k2 terms, though forced to zero by the optimal P^*_k, can become positive if the asked-for $\Delta P_k < 0$ is sufficiently generous. We have already shown (Proposition 1) that for fine enough discrimination, $\tau_i \equiv \Delta\tilde{\pi}_i/\Delta\pi_i$ is a constant. But note that the second term

$$(\sum_{k2}\Delta\pi_{k2})/\Delta\pi_i = \sum_{k2}\Delta P_{k2}[Q^*_{k2} - \beta(P^*_{k2} - \mu)Pop_{k2}]\}/\Delta P_i[Q^*_i - \beta(P^*_i - \mu)Pop_i$$

must now rise, since some of the difference terms $[Q^*_{k2} - \beta(P^*_{k2} - \mu)Pop_{k2}]$ become positive, and the ratio $\sum_{k2}\Delta P_{k2}/\Delta P_i$ is set by MFC. Thus the lower limit which defines τ_i must rise as $\Delta P_k < 0$ rises in absolute value.

Second Corollary: At any fineness of price discrimination that is less than maximal, if high enough levels of price discounting are asked for, the threat multiplier for a linear demand system must converge to a stable point – that of the finest possible level of discrimination.

Proof: As $\Delta P_k < 0$ gets larger in absolute value, there are fewer zero-valued $\Delta\pi_{k2}$ terms. By the constancy of the ratio $(\sum_{k1}\Delta\pi_{k1})/\Delta\pi_i$, τ_i must converge to c_i, as shown in Proposition 1.

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