

Reference Prices, Cross-Border Information Flows, and Market Segmentation: The Case of Antiretrovirals*

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October 2010

Abstract

This paper examines how intellectual property rights' enforcement in poor countries may have unintended consequences given a rapid flow of price information across national borders. Such flows may affect market segmentation between rich and poor countries if consumers in rich countries incorporate prices from poor countries into their reference prices for domestic purchases. Firms in turn may not price discriminate across rich and poor countries if their markets are not segmented. The paper begins by confirming anecdotal evidence of incomplete price discrimination across countries for the case of the antiretrovirals (*ARVs*) used to treat the *Human Immunodeficiency Virus (HIV)*, introducing a new cross-country data set from a collaboration with the *Campaign for Access to Essential Medicines* run by the well-known NGO *Médecins Sans Frontières (MSF)*. After establishing *ARVs*' lack of price dispersion across countries with different income levels, the paper presents a model that illustrates how such a price distribution is an optimal response by firms given consumers in wealthy countries who engage in reference pricing and can easily gather information about prices in other, poorer, countries.

*I thank George Akerlof, Pranab Bardhan, Paul Gertler, Richard Gilbert, Monica Hirst, Jenny Lanjouw, Cécile Macé, Carmen Pérez-Casas, Mike Scherer, and Catherine Wolfram for helpful comments. Any errors are of course my own. I am particularly grateful to Benjamin Hellerstein for his programming assistance. Christina Marsh, Ramneek Nakai, and Sharad Tandon provided excellent research assistance. Financial support from the Social Science Research Council's Program on Global Security and Cooperation, sponsored by the John D. and Catherine T. MacArthur Foundation, is gratefully acknowledged. The views expressed in this paper are those of the author and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System. Address: International Research Group, Federal Reserve Bank of New York, 33 Liberty Street, New York, NY 10045; email: rebecca.hellerstein@ny.frb.org.

I Introduction

“The battle over the price of *AIDS* medications in Africa is focusing new attention on pharmaceutical companies’ pricing practices for many drugs in the *U.S.*” *Los Angeles Times*, 25 March, 2001

When the magnitude of the *AIDS* crisis in Africa, Asia, and Latin America became clear in the late 1990s, a controversy erupted over the prices charged for the antiretroviral drugs (*ARVs*) used to treat the disease.¹ *ARVs* were not widely available or affordable in developing countries, public health advocates claimed, and in absolute terms, their prices were sometimes set as high or higher in poor countries such as Uganda or Tanzania as in wealthy countries such as the U.S.²

This apparent lack of price discrimination across rich and poor countries seemed puzzling from a profit-maximizing perspective if firms were, in fact, trying to sell the drugs in poor countries. Originator firms, that held patents on individual *ARVs*, responded that the prices used for the comparisons reflected other costs imposed by individual countries, including tariffs, taxes, and distribution markups, but did not release data on their cross-country pricing policies or production costs. Though this type of information is generally considered proprietary, and is often kept confidential across a range of industries, it is interesting that the originator firms went one step further, actively campaigning against efforts by such multilateral agencies as the World Health Organization (WHO) to collect data that would allow cross-country price comparisons.³⁴

¹*AIDS* stands for Acquired Immune Deficiency Syndrome.

²The type of pair-wise comparisons used in these discussions is illustrated in Figure 2.

³Donald G. McNeil, Jr. "Patent Holders Fight Proposal on Generic AIDS Drugs for Poor," *The New York Times*, May 18, 2000.

⁴The resulting lack of data reportedly affected efforts by researchers to assess the likely impact of the *TRIPS* agreement on prices and, thus, welfare. The 1995 World Trade Organization’s *TRIPS* agreement (Agreement on Trade-Related Aspects of Intellectual Property Rights) required enforcement of intellectual property rights, including pharmaceutical patents, in developing countries by the year 2006. Most developing

The more general question raised by this policy debate was how cross-border information flows may affect the structure and functioning of the international economy. Such flows have risen with the growth in electronic communication technologies such as the Internet. As they increase consumers' information about prices in other countries, will national market segmentation erode?

This paper examines how a rapid flow of price information across borders may affect market segmentation between rich and poor countries if consumers in rich countries incorporate prices from poor countries into their reference prices for domestic purchases. It explores how intellectual property rights' enforcement in poor countries may have unintended consequences given a rapid flow of price information across national borders, and the implications for the enforcement of intellectual property rights in poor countries. One obvious consequence is that firms may not price discriminate across rich and poor countries if their markets are not segmented. As consumers learn about prices in other countries, a firm may not be able to set prices in a poor country, for example, without affecting its revenue in other, wealthier markets. The paper's model shows that market segmentation can break down even without any transfer of goods across national markets, if consumers incorporate information about prices in other countries to update their reference prices.

The paper begins by confirming anecdotal evidence of incomplete price discrimination across countries for the case of the *ARVs* used to treat *Human Immunodeficiency Virus (HIV)*, introducing a new cross-country price data set for *ARVs* from a collaboration with the *Campaign for Access to Essential Medicines* run by the well-known NGO *Médecins Sans Frontières (MSF)*. The campaign gathers information on drug prices in developing countries

countries did not enforce patent rights prior to the *TRIPS* agreement. In the U.S., a firm has a legal monopoly on a drug for twenty years after a patent is filed. This convention was universalized by the *TRIPS* agreement: Every WTO member was expected to grant patent protection for a minimum of 20 years to new drugs.

for their own procurement needs and to produce policy reports. The paper examines these drugs' cross-country price distributions in 2000, when there was little generics competition, and in 2003, when there was widespread generics competition. It builds on the work of Scherer and Watal (2001), who found *ARV* prices to be randomly distributed across countries with respect to per-capita income through 1999.⁵ This paper's data, picking up where their data end, in the year 2000, show that firms may not price discriminate across countries if they face no competition. The relationship between drug prices and consumers' ability to pay strengthens considerably with some price competition among firms, all else equal. The paper also finds that data on the structure of health expenditures do not explain *ARVs* cross-country price variation.

After establishing *ARVs* lack of price dispersion across countries with different income levels, the paper presents a model that illustrates how such a price distribution reflects the optimal marketing response by firms given consumers in wealthy countries who engage in reference pricing and can easily gather information about prices in other, poorer, markets.

The rest of the paper proceeds as follows. The next section describes the data, and Section 3 examines the setting and assesses whether firms price discriminate across rich and poor countries by comparing the cross-country variation of selected *ARVs* prices and of per-capita income. Section 4 presents a stylized model to explain why drug prices may covary positively with per-capita income only when generics are widely available. The model allows for the breakdown of international market segmentation even in the absence of cross-border reimportation. The final section considers some policy implications of the paper's findings.

⁵It also builds on a series of careful studies by Danzon and co-authors (e.g. Danzon and Chao, 2000; Danzon and Furukawa, 2008; Danzon and Towse, 2003) documenting that pharmaceutical prices covary with per-capita income across high- and middle-income countries.

II Data

Antiretrovirals are drugs that inhibit the actions of enzymes *HIV* needs to reproduce, thus extending the length and quality of life of infected people. *ARVs* are comprised of two major drug classes, reverse transcriptase inhibitors and protease inhibitors (*PIs*). The first class can be divided into two additional groups: nucleoside reverse transcriptase inhibitors (*NRTIs*) and non-nucleoside reverse transcriptase inhibitors (*NNRTIs*). Therapies that combine drugs from the two classes suppress *HIV* most effectively.

The price data come from a collaboration with the *Campaign for Access to Essential Medicines* run by the well-known NGO *Médicins Sans Frontières (MSF)*. This campaign gathers information on drug prices in developing countries for their own procurement needs and to produce policy reports. The data include selected *ARV* import prices for the years 2000 and 2003 for 27 countries from North America, Latin America, Africa, and Asia.⁶ A product is defined as one unit (a single capsule or tablet) of a particular *ARV*. The sample includes prices for the following products: *NRTI*'s: *Didanosine*, *Lamivudine*, *Stavudine*, and *Zidovudine*; *NNRTI*'s: *Efavirenz* and *Nevirapine*; and *PI*'s: *Indinavir*, *Nelfinavir*, and *Saquinavir*. The *MSF* data are supplemented with comparative cross-country measures of per-capita gross domestic product (*GDP*) on a purchasing-power-parity basis from the World Bank's *World Development Indicators* for 2003. Data on the share of health expenditure paid by public institutions come from the *WHO*'s 2001 *World Health Report*.

⁶Most of the prices are CIF, "Cost, Insurance, and Freight." The seller pays the costs and freight to transport the good to the destination port. The buyer is responsible for any additional costs after delivery to the port.

III Setting and Empirical Analysis

III.1 Setting

When the magnitude of the *AIDS* crisis became apparent in the late 1990s, a series of reports were published by various NGOs claiming that in absolute terms, *ARV* prices were generally set as high or higher in the Least Developed Countries (*LDCs*) as in wealthy countries such as the U.S. In the wake of this controversy, *ARV* prices declined precipitously from 2000 to 2003 in developing economies, as described in more detail below. Why did the international distribution of prices change so dramatically over such a short period? This section documents the background to these changes, how they followed increased generic competition and the introduction by originator firms of country-specific discounts for *LDCs*.

First, in May of 2000, originator firms that owned the patents on various *ARVs* announced a series of voluntary price reduction programs for residents of low-income countries through a new public-private partnership called the Accelerated Access Initiative (*AAI*).⁷ The firms also made price offers through bilateral negotiations with individual governments. In addition, from 2000 on, the low prices of *ARVs* produced by Indian and Brazilian generics firms began to put pressure on originator firms to reduce their prices in low- and medium-income countries. For example, competition from generics producers in India and Brazil forced the average branded price of an *AIDS* triple-combination therapy from \$10,439 per year to less than \$1,000 per year between 2000 and 2001.⁸ Price competition between *ARV*

⁷The *AAI* was a partnership between five pharmaceutical companies and several United Nations organizations to improve the provision of *AIDS*-related treatment in developing countries. The firms are *Boehringer Ingelheim*, *Bristol-Myers Squibb*, *Glaxo Wellcome*, *Merck & Co., Inc.*, and *F. Hoffmann-La Roche*. They made their price offers to countries classified as "Least Developed Countries" (*LDCs*) by the World Bank or in sub-Saharan Africa. *Merck* and *Roche* also publicized price offers for medium-income countries.

⁸Two legal cases between the U.S. and Brazil and South Africa also energized the opposition to the *TRIPS* agreement during this period. In February 1998 multinational pharmaceutical manufacturers filed a suit against the South African government for its "Medicines and Related Substances Control Amendment Act" passed in 1997. The manufacturers argued that the Act violated the *TRIPS* agreement. The Act

manufacturers entered a new phase in February 2001 when the Indian generics manufacturer *Cipla* declared it would sell a triple-combination *ARV* treatment for \$350 per patient per year.

In the midst of this controversy over prices, in November of 2001 the Fourth *WTO* Ministerial Conference met in Doha, Qatar. There, member states sought to reinterpret the original terms of the *TRIPS* agreement to support governments' rights to protect their citizens' health. The resulting *Doha Declaration* granted *LDCs* an additional ten years, until 2016 instead of the original date of 2006, to implement *TRIPS* fully as *WTO* members. It also established the principle that member states could privilege public health above the protection of intellectual property rights, broadening the grounds on which a country could issue a compulsory license for a drug. Countries could determine internally when a national emergency was at hand: No multilateral authority needed to make this determination as in the past. The agreement also reiterated the general principle that compulsory licenses could be issued without a national emergency.

Developing countries still could not import generic *ARVs*, however. The Doha agreement stated that developing countries could issue compulsory licenses to override a patent in the interest of public health, but only to produce a drug *domestically*. Medium-income countries with established pharmaceutical industries could export generics to low-income countries only through 2005. This was seen as problematic, as pharmaceutical manufacturing was not feasible for most low-income countries with high rates of *AIDS*. In particular, most

legalized the importation of patented medicines from other countries, so-called "parallel importation." Both the US and the EU pressured the South African government to change the law. As the case went to court in May 2000 the NGO community began a campaign to protest the suit. In April 2001 the case was unconditionally dropped. A second case involved Brazil. The United States brought Brazil before the *WTO* dispute settlement body to protest a law that holders of Brazilian patents manufacture their product domestically. The US claimed this law infringed on US patent holders' rights. The NGO community pressured the U.S. to drop the case, and in June 2001 it did.

sub-Saharan African countries' small domestic market and limited industrial capacity made domestic pharmaceutical production infeasible. The Doha agreement did not speak to the export of generics medicines from such medium-income countries as India, Brazil, or China to *LDCs* and so it did not resolve the issue of drug availability in low-income countries. Drugs produced under a compulsory license in Brazil, for example, could not be exported to Ghana or the Sudan. This was resolved in August 2003 in Cancun, Mexico, when *WTO* members agreed that developing countries could import generic variants of drugs under patent to address such public health threats as malaria, *AIDS*, or tuberculosis. This agreement enabled low-income countries to import generics from medium-income countries rather than being forced to set up domestic production to have access to cheaper drugs. In the wake of the Doha and Cancun agreements, imports of generics *ARVs* to *LDCs* surged, and prices fell.

Finally, and in a related development, from 2002 to mid 2003 a number of Latin American countries bargained collectively with originator and generics firms to purchase *ARVs* under the auspices of the Pan American Health Association (*PAHO*). The agreements that resulted reduced *ARV* prices in most of Latin America by the middle of 2003.

III.2 Analysis

Did originator firms price discriminate across rich and poor countries when operating under a *TRIPS*-like intellectual property regime in the year 2000, without competition from generics producers? To address this issue, Table 1 reports the correlations between selected drugs' 2000 and 2003 prices and per-capita *GDP* calculated on a purchasing-power-parity basis (PPP *GDP*). Per-capita *GDP* is used on a PPP basis to stack the deck towards finding evidence of price discrimination. Because the price level tends to be lower in developing

economies, once one controls for this fact, the differences in per-capita GDP between rich and poor countries narrow. Despite this compensation, the correlation is low (though positive) for most of the drugs' year 2000 prices: 0.19 for *Didanosine*, 0.29 for *Efavirenz*, 0.29 for *Stavudine*, and 0.41 for *Zidovudine*. The correlation is negative for one drug, *Abacavir*, at -0.49. In 2003, in contrast, the correlation is high and above 0.9 for every *ARV* in the sample: It is 0.92 for *Didanosine*, 0.94 for *Efavirenz*, 0.94 for *Stavudine*, and 0.95 for *Zidovudine*.

Building on these correlations, Figure 1 compares the relationship between selected *ARVs* (*Didanosine*, *Efavirenz*, and *Zidovudine*) prices relative to the U.S. price (to be consistent with Scherer and Watal, 2001) and finds the relationship is much stronger in 2003 than 2000. Similarly, Figure 2 shows the prices for these three *ARVs*, in the U.S., Spain, emerging economies with significant generics manufacturing capability (Thailand, India, and Brazil), and selected African countries with high *HIV* incidence, including Cameroon, South Africa, Uganda, Senegal, Kenya, and Tanzania. It compares the prices in 2000 and 2003 to each country's per-capita GDP which is indexed to the U.S. price in 2000. The per-capita GDP measure is calculated on a purchasing-power-parity basis, again to stack the deck toward finding evidence of price discrimination. In 2000, each drug's prices appeared higher than the per-capita GDP index for every country in the sample except the U.S., Spain, and for *Zidovudine*, two of the middle-income countries with large domestic pharmaceutical industries, Brazil and Thailand. By 2003 each drug's prices had fallen across emerging markets and are much closer to the per-capita GDP index for the sample's low-income countries than previously. They were also far below the per-capita income index for the three middle-income countries with large domestic manufacturing industries: Brazil, India, and Thailand.

Table 2 reports results from simple tests of cross-border price discrimination for each

type of *ARV* in the sample. These are panel regressions, by type of *ARV*, of country-level *ARV* prices on per-capita income, with individual drug fixed effects:

$$PRICE_{it} = \beta_0 + \beta_1 GDP_PC_{it} + \beta_2 X_i + \varepsilon_{it}$$

where i denotes drug, t denotes time (for either the year 2000 or 2003), and X_i is the individual drug fixed effect. For the year-2000 prices, when there was little generics competition, the coefficients on per-capita income cannot be distinguished statistically from zero for two of the three types of *ARV* considered: *NRTI*'s and *NNRTI*'s. The coefficient on *PI*'s is positive and significant but not very large, at 0.18. For the year-2003 prices, when generics competition was widespread, the per-capita-income coefficients are positive and statistically significant for all three types of *ARV*: 0.61 for *NRTI*'s, 0.38 for *NNRTI*'s, and 0.49 for *PI*'s.

Why do the year-2000 prices have such a weak relationship to per-capita income? The seemingly most plausible explanation is that countries have different degrees of bargaining power with respect to firms depending on the structure of their health expenditure systems. Such systems differ in important ways across countries with different income levels. Consumers negotiate drug prices individually in most low-income countries, while in most high-income countries public-health institutions or private insurance firms negotiate drug prices on consumers' behalf, exploiting their monopsony power to bargain for (or regulate, via controls) lower prices. As countries' average per-capita income rises, the share of total health-care expenditures paid for by public institutions also rises. One would thus expect prices to be higher relative to per-capita income in low-income countries than in high-income countries given public institutions' ability to bargain for lower prices.

Table 3 reports the coefficients from regressions of *ARV* prices on per-capita income and on the share of total health expenditure paid for by public institutions. In 2000,

the per-capita income coefficient is positive and significant at 0.14 while the coefficient on the government's share of health expenditure is not significant. In 2003, again only the coefficient on per-capita income is significant at 0.54. Regressions that control for the share of out-of-pocket expenditure and of private-health-insurance expenditure in total health expenditure produce similar results: Controlling for cross-country variation in the structure of health expenditure strengthens the relationship between per-capita income and *ARV* prices in 2000, but not dramatically, and has little effect on the relationship in 2003.

IV Model

The previous section documents a puzzling stylized fact about the international distribution of *ARV* prices in the year 2000: Originator firms, firms that hold the patent on a drug, did not price discriminate across rich and poor countries when they faced no generics competition. This section introduces a model to explain this stylized fact as the profit-maximizing response of originator firms to the incentives they face in the global pharmaceutical market under a *TRIPS*-like intellectual-property regime.

The model examines how consumers' price perceptions affect originator firms' behavior, where the difference between the actual and the reference price of a good conveys utility directly, and so affects consumer behavior. The model then illustrates the optimal marketing strategy firms adopt in response to consumers' behavior which may explain the otherwise puzzling lack of price discrimination by pharmaceutical firms across rich and poor countries.

A number of studies have established broad-based evidence that reference prices influence consumers' purchasing behavior.⁹ A large body of literature in marketing (originated by Helson 1964) suggests consumers use past product prices and other factors such as advertised

⁹For a summary of the literature, see Kalyanaram and Winer (1995).

prices to form reference prices, and that lower reference prices act like an inward shift in a demand curve. The model incorporates these insights from the reference-pricing literature, most notably from Putler (1992), by having consumers compare the price they pay for a product (referred to throughout the paper as the actual price) to their reference price for the product.¹⁰ Consumers experience a utility gain if the actual price is lower than the reference price and a utility loss if the actual price is higher than the reference price.

IV.1 Demand

Suppose we observe demand for a product in two countries: a rich country, country 1, and a poor country, country 2. Let the product be one dosage of a drug. Let a market be the total demand for the product in one time period and in one country. Reference prices are formed by the consumer before she makes a purchase, and are viewed as exogenous. They do not affect the consumer's budget constraint but rather affect behavior by entering the utility function directly. Each country has one representative consumer. The difference between the actual price of a product and its reference price produces a marginal gain or loss experienced by the consumer as part of her utility in purchasing the good. The marginal loss for good i is given by

$$l_i = I_i(p_i - rp_i),$$

and the marginal gain by

$$g_i = (1 - I_i)(rp_i - p_i),$$

where rp_i is the reference price for good i , p_i is the actual price, and I_i is an indicator function that indicates if the consumer perceives the price of the good as a utility loss or

¹⁰Building on these insights, Thaler (1985) argues that firms benefit from marketing techniques that may raise a product's reference price, such as high suggested retail prices.

not: It is equal to 1 if the actual price is greater than the reference price ($p_i > rp_i$), and 0 otherwise. The total effective loss or gain for good i given a per-unit loss or gain is given by

$$L_i = l_i x_i, \tag{1}$$

$$G_i = g_i x_i, \tag{2}$$

where L is the total loss, G is the total gain, and x is the amount purchased of good i . When deciding how much of good i to purchase, the consumer also determines the level of utility associated with paying the actual price, that is, the utility or disutility associated with purchasing the good. Each consumer can purchase the product only in her domestic market. In each period, the consumer maximizes the utility function

$$\max_x U(x, L, G)$$

subject to the budget constraint

$$\sum_{i=1}^n p_i x_i = M x_i$$

where x_i is the quantity consumed of good i , L_i is the perceived loss from purchasing good i at price p determined by (1), G_i is the perceived gain from purchasing good i at price p determined by (2), and M is the predetermined expenditure for the period. First-order conditions are positive and second-order conditions are negative with respect to changes in the quantity consumed ($U_x > 0, U_{xx} < 0$) or the extent to which the actual price is lower than the reference price ($U_G > 0, U_{GG} < 0$). First-order conditions are negative and second-order conditions are positive for the extent to which the actual price is higher than the reference price ($U_L < 0, U_{LL} > 0$). The utility function is concave for consumption and for gains, and convex for losses, consistent with Tversky (1977). First-order conditions are

given by

$$\begin{aligned} \frac{\partial U}{\partial x_t} + l_t \frac{\partial U}{\partial L_t} + g_t \frac{\partial U}{\partial G_t} - \lambda P_t &= 0 \\ M - \sum_{i=1}^n P_i x_i &= 0 \end{aligned}$$

The marginal utility for a good will depend on the level of consumption of that good and the level of gain or loss associated with the good. Marshallian demand functions are given by

$$x_t = x_t(p, I(p - rp), (1 - I)(rp - p), M).$$

The Marshallian demand function includes not only actual prices and income, but also marginal gains and losses, and can be used to predict how reference price formation affects consumer purchasing behavior.

Each consumer costlessly observes the price in her own market, and her reference prices are determined by prices from past purchases, and from information about prices in other markets which include other countries. The model assumes that a consumer's reference price for product i is given by the mean of the reference price distribution, which includes domestic and foreign price quotes.

What happens to the demand for good i in country 1 when consumers in country 1 learn the price of good i is significantly lower in country 2? This will reduce these consumers' reference price for good 1, which will in turn cause demand for the good to fall in country 1, even if the actual price remains unchanged. Figure 3 examines the effect of a decrease in the reference price of good i after the initial price equals the reference price. Even without any change in the actual price, the utility loss from the decrease in the reference price (represented by movement from point A to point B) will reduce demand for good i relative

to good j . Figure 4 illustrates how the demand for good i shifts inwards following a decrease in its reference price. Figures 3 and 4 together illustrate how with a free flow of information, a price in one market may affect reference prices in a separate segmented market, affecting demand there without any physical transport of the good across national borders.

One may interpret this effect in several ways. First, a number of OECD countries use reference pricing to set the regulated prices of domestic drugs. Danzon and Epstein (2008) have shown how these policies may result in delayed launch of new drugs in lower-income countries within the European Union, a spillover effect of a wealthy government's pricing policies on the availability and pricing of these drugs in other lower-income markets.¹¹ Second, consumers in wealthy countries may engage in informal reference pricing, which is facilitated by the rise in cross-border electronic communications. Such informal referencing is particularly interesting in the case of U.S. consumers, who account for roughly 50 percent of pharmaceutical firms' global revenue. U.S. consumers' demand for drugs may decline as they incorporate low foreign prices into their reference prices for individual drugs. Even with limited alternatives to substitute to, a large decline in the reference prices for individual drugs could affect search behavior, spurring them to find ways to purchase drugs from abroad, or making them more amenable to the imposition of government pricing regulations in the domestic market.

¹¹In related results, Kyle (2007) finds that pharmaceutical firms delay the launch of new drugs into price-controlled markets, and Lanjouw (2005) provides evidence that price controls lower the probability of a new drug's launch in high-income countries, but not in low-income countries, where it does, however, delay the date of the launch. As Lanjouw (2005) notes, "less than one-half of the new pharmaceutical molecules that are marketed worldwide are sold in any given country, and those that are sold are often available to consumers in one country only six or seven years after those in another."

IV.2 Supply

On the supply side, let there be a monopolist that produces drug i . The monopolist chooses its price in each of the two segmented national markets to maximize the net present value of its profits

$$E \sum_{t=1}^T \Pi_{it} = E \sum_{t=1}^T [(p_{i1t} - mc_{it}) x_{i1t} (p_{1t}, rp_{1t}(p_{2t}, p_{1t-1}), M_1) + (p_{i2t} - mc_{it}) x_{i2t} (p_{2t}, rp_{2t}(p_{1t}, p_{2t-1}), M_2)]$$

where p_{ijt} is the price of the product i in country j at time t , rp_{ijt} is the reference price of the product i in country j at time t , M is the predetermined expenditure for the period, x_{ijt} is the quantity demanded of the drug i in country j at time t , and mc_{it} is the marginal cost to produce the drug which does not vary across countries. Assuming the firm sets prices to maximize profits, the price p_{jt} must satisfy the first-order conditions in each period which can be rewritten to give expressions for the determinants of the product's price in each country:

$$\begin{aligned} p_{i1t} &= mc_{it} - \frac{x_{i1t}}{\frac{\partial x_{i1t}}{\partial p_{i1t}}} - (p_{i2t} - mc_{it}) \frac{\frac{\partial x_{i2t}}{\partial rp_{2t}} \frac{\partial rp_{2t}}{\partial p_{i1t}}}{\frac{\partial x_{i1t}}{\partial p_{i1t}}} \\ p_{i2t} &= mc_{it} - \frac{x_{i2t}}{\frac{\partial x_{i2t}}{\partial p_{i2t}}} - (p_{i1t} - mc_{it}) \frac{\frac{\partial x_{i1t}}{\partial rp_{1t}} \frac{\partial rp_{1t}}{\partial p_{i2t}}}{\frac{\partial x_{i2t}}{\partial p_{i2t}}} \end{aligned} \quad (3)$$

If the national markets were perfectly segmented, each country's price would be a function of the marginal cost and the demand elasticity in that country alone. The third term of equation (3) indicates that country 2's price is less responsive to changes in the domestic demand elasticity than it would be in completely segmented markets where the $(p_{i1t} - mc_{it}) \frac{\frac{\partial x_{i1t}}{\partial rp_{1t}} \frac{\partial rp_{1t}}{\partial p_{i2t}}}{\frac{\partial x_{i2t}}{\partial p_{i2t}}}$ term would equal zero, as the sign on the term is positive. As markups rise in country 1, they rise in country 2, subject to the responsiveness of de-

mand in country 2 and country 1 to changes in p_2 . It also indicates that the firm's price in country 2 may respond to changes in its price in country 1, which would not be the case with completely segmented markets. If the monopolist raises the product's price in country 1, it should also raise it in country 2 to maximize profits: $\frac{\partial p_{2t}}{\partial p_{1t}} \geq 0$.

Market segmentation fails in one important and unconventional way in this model. The ability of consumer 1 to learn costlessly the price paid by consumer 2 implies a market-segmentation breakdown. Increased flows of information across national borders mean that consumers in one country are more likely to learn what foreign consumers pay for a product than they did previously. If the monopolist does not want to lose profits in country 1 following a rise in information flows, it must increase the product's price in country 2, perhaps even to the point where it exceeds consumer 2's income. This is simply profit-maximizing behavior given consumers in country 1 who form reference prices using price information from country 2.

A question that naturally arises is if originator firms have true monopolies, then the reference price formation of consumers in country 1 should not impact firms' marketing strategies, as long as demand is sufficiently inelastic. But consumers may still impose government pricing regulations on firms. In this interpretation of the model, originator firms have market power derived from consumers' uncertainty about their marginal costs. Improved information about such costs, from lower prices in other segmented markets, may cause consumers to be willing to bear the costs to establish a national system of price controls. If one assumes that the manufacturer always sets its price to be greater than or equal to its marginal cost, then the lowest price charged in another country provides an upper bound on the manufacturer's marginal cost. Consumer 1 has imperfect information about manufacturers' markups over marginal cost: With improved information, he can

calculate if the fixed costs (and welfare losses) from imposing a system of price controls are greater than the manufacturer's markups, that is, would cause the manufacturer to exit. If Consumer 1 has a notion of a fair markup over marginal cost, when this fairness ideal is violated he may punish the monopolist by imposing price controls even if he must bear some cost to do so.

V Conclusion

This study finds that *ARV* prices had a weak relationship to countries' per-capita incomes in the year 2000 before the onslaught of generics competition in this market. By the year 2003 the dramatic changes in the international distribution of *ARV*s strengthened significantly the relationship between *ARV* prices and per-capita income. The paper then develops a model in which the reference pricing of wealthy consumers causes a monopolist to consider their reactions when setting prices for poor consumers in a separate segmented market.

Firms' first-best strategy is always to price discriminate given the conditions to do so. Cross-border information flows may erode the conditions necessary for price discrimination in the global pharmaceutical market as firms' profits depend in part on consumers in high-income countries *not* using price information from poor countries to set their own reference prices. Firms' profit losses in high-income markets following the release of information about their prices may outweigh expected profit gains from setting prices that poor countries' consumers can afford to pay.

The model speaks to the possible welfare costs of the global monopolies to be established from the implementation of the 1995 World Trade Organization's *TRIPS* agreement. The agreement (with subsequent amendments) requires pharmaceutical patents to be enforced in most developing countries by the year 2016. The agreement's supporters argue that the

costs borne by those consumers in developing countries who pay higher drug prices in the short run will be smaller than the benefits they reap from access to better drugs over the long run. This paper's findings imply that information technology's impact on the flow of price information between rich and poor countries may increase the costs for poor countries to implement *TRIPS*, via higher drug prices, perhaps considerably.

The paper's empirical results show that when market forces were brought to bear in the *ARV* market between 2000 and 2003 through the increased activities of generics producers, the distribution of prices did move closer to the distribution of per-capita income across countries. The question is why cross-border pricing externalities played such an important role in the monopoly case in 2000, which is the default model for the international pharmaceutical market, not 2003, which due to the attention by the media, NGOs, and the unusual challenges by generics firms to originator firms was an aberration.

Despite the substantial media interest in this issue in recent years, trade policymakers have not yet contended with the effects of this unusual type of market failure, brought about by a rapid flow of information across national borders, and the implications for welfare in developing countries going forward. In the long run, the enforcement of intellectual property rights in the least developed economies should be welfare enhancing, as it will encourage innovation. But in the short run, the breakdown of market segmentation outlined here is a market failure with potentially first-order welfare effects via the effects on pharmaceutical prices. In the near term, policymakers should explore measures to support the segmentation of markets between rich and poor countries. One simple recommendation would be to streamline the regulatory process to facilitate firms' repackaging (i.e. renaming) of their products for developing economies – a process which is currently somewhat cumbersome.

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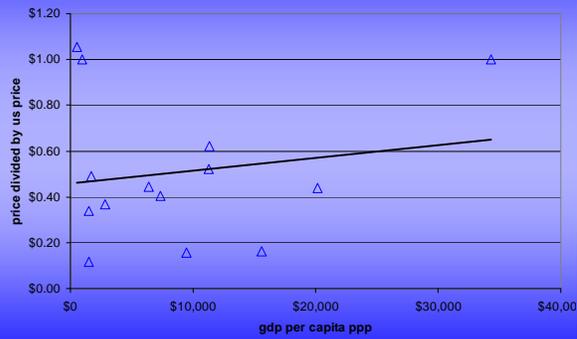
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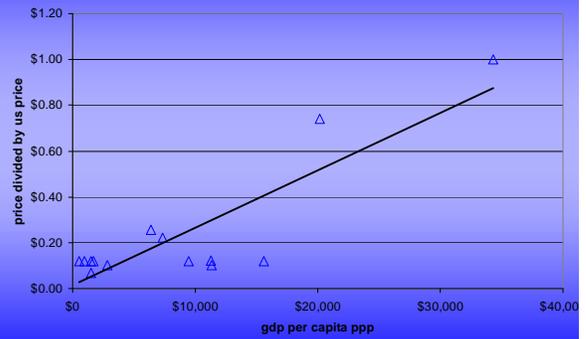
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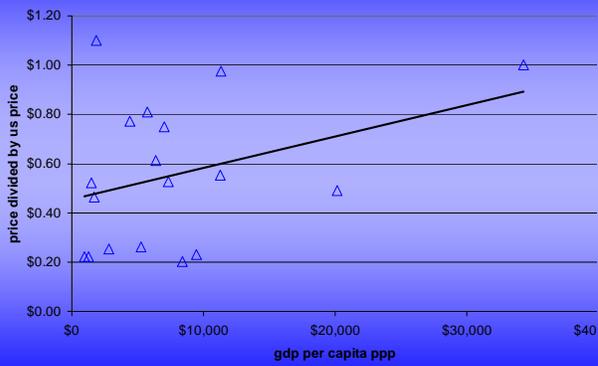
Didanosine prices against income, 2000



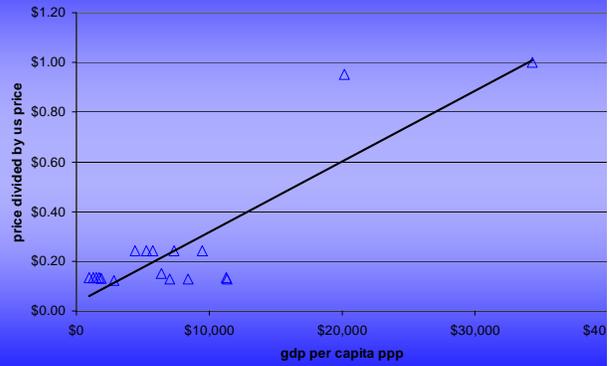
Didanosine prices against income, 2003



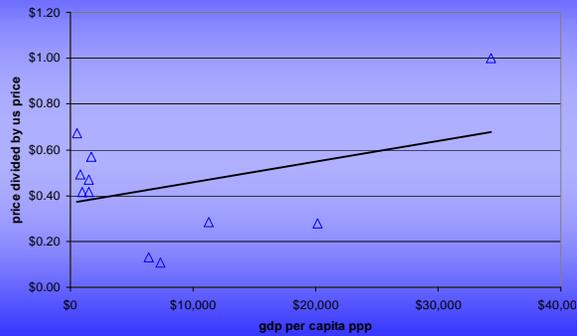
Efavirenz prices against income, 2000



Efavirenz prices against income, 2003



Zidovudine prices against income, 2000



Zidovudine prices against income, 2003

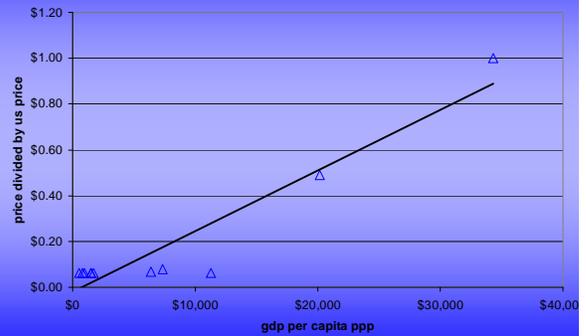


Figure 1: The Relationship Between ARV Prices and Per-Capita Income in 2000 and 2003. Sources: MSF, World Development Indicators.

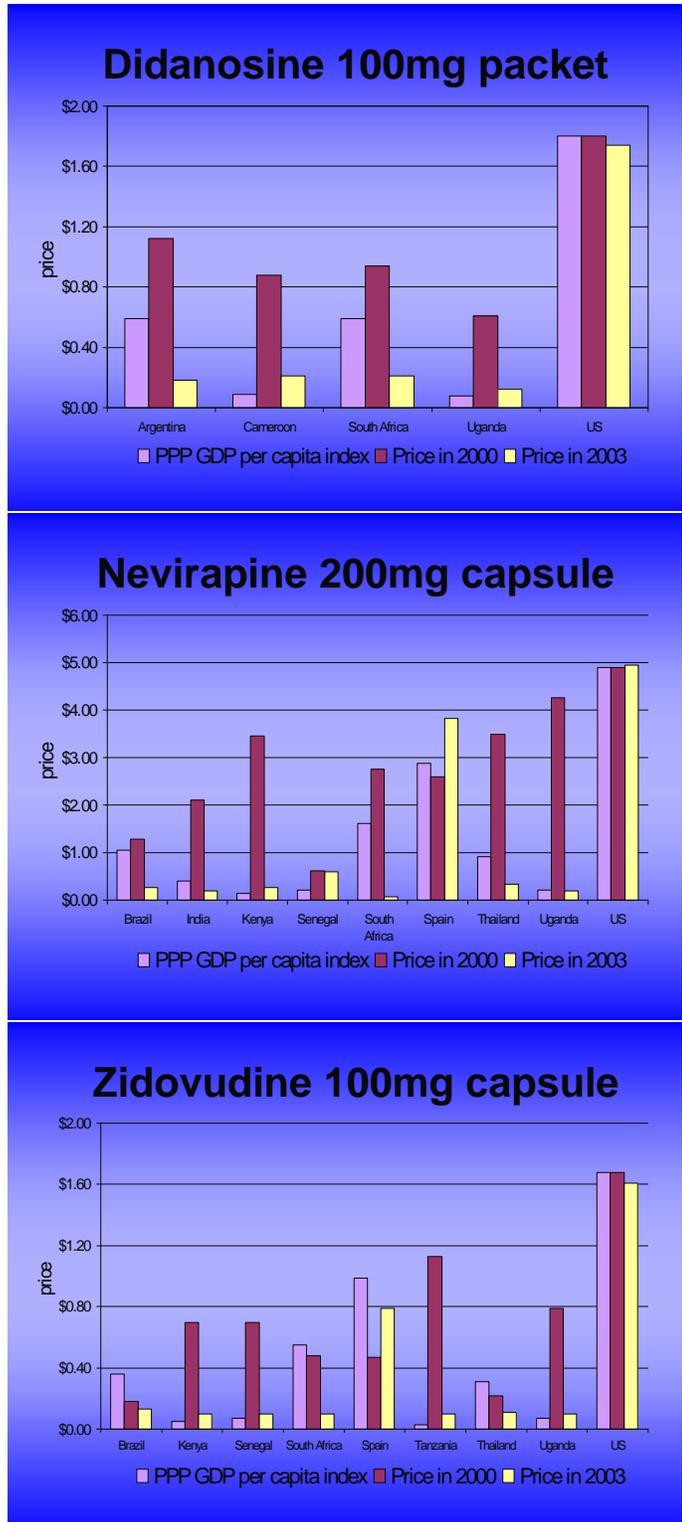


Figure 2: A Cross-Country Comparison of Per-Capita GDP Indexes (on a PPP basis) and Selected ARV Prices. Sources: MSF, World Development Indicators.

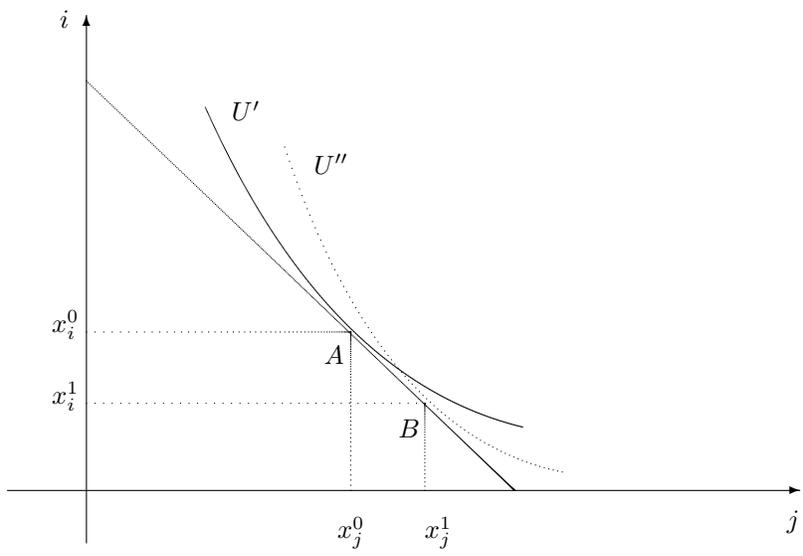


Figure 3: The Effect of Lowering the Reference Price of Good i

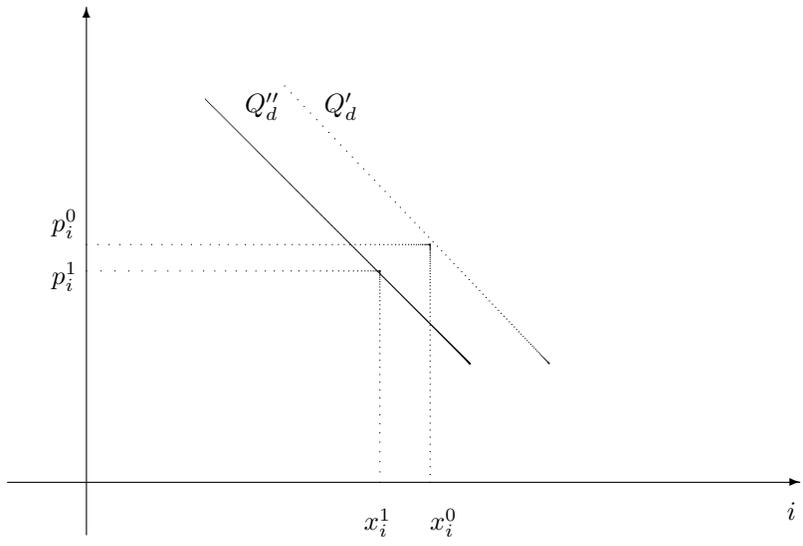


Figure 4: Demand Curves for Good i at Reference Prices p_i^0 and p_i^1

	Drug	Price in 2000	Price in 2003
PPP GDP per capita	Abacavir	-.49	.99
	Combivir	.87	.92
	Didanosine	.19	.92
	Efavirenz	.29	.94
	Lamivudine	.44	.92
	Stavudine	.29	.94
	Zidovudine	.41	.95

Table 1: *Correlations between PPP GDP per capita and selected drugs' prices.* Source: MSF.

Drug Class	Price in 2000	Price in 2003
NRTI's	.05 (.50)	.61 (6.13)*
NNRTI's	-.02 (-.19)	.38 (4.07)*
PI's	.18 (2.29)*	.49 (4.70)*
All ARV's	.09 (1.50)	.52 (8.61)*

Table 2: *Results from regressions of ARV prices on per-capita income.* Panel regressions with fixed effects for individual drugs. T-statistics in parentheses under coefficients: Those starred are significant at the 5-percent level. Source: MSF.

	Price in 2000	Price in 2003
Per-capita GDP (\$1,000)	.14 (1.99)*	.54 (7.54)*
Public health expenditure (%)	-.13 (-.65)	.06 (.30)
Constant	-.37 (-.37)	-5.94 (-8.07)*
Observations	113	113
R^2	.03	.36

Table 3: *Results from regressions of ARV prices on per-capita income and on the share of public expenditure in total health expenditure, for the years 2000 and 2003.* Panel regressions with fixed effects for individual drugs. T-statistics in parentheses under coefficients: Those starred are significant at the 5-percent level. Source: MSF.