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Polarization & pricing to the rich

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Income polarization directly affects monopoly pricing and profits when a monopolist cannot segment markets. When income and price elasticity of demand are negatively correlated, increasing income disparity ultimately leads the monopolist to target the rich at the exclusion of the poor. This paper uses a simple model to demonstrate how income polarization, as distinct from income inequality, affects monopoly price and profit in such a situation. Without income polarization, price increases and profit decreases with income disparity when the monopolist targets the rich. With income polarization, price increases sharply and profit increases with income disparity when the monopolist targets the rich. Preliminary evidence suggests that pharmaceutical prices may indeed increase with polarization.

I. Introduction

Income distribution profoundly shapes social, economic and political structure. Rising income disparity since 1980 has fueled a broad interest in the economic implications of income distribution (Atkinson and Bourguignon, 2000), including its effect on prices. For example, income distribution may affect retail prices because lower-middle income households allegedly shop more aggressively for low prices, thereby driving down prices (Frankel and Gould, 2001).[1] This note uses a simple model to illustrate how income distribution can affect prices even more directly by influencing a monopolist's pricing strategy. While the model generally reinforces the well-known finding that price discrimination can increase social welfare (Varian, 1985), it highlights how this result hinges on income polarization as distinct from other features of the income distribution.

Concern about access to essential medicines has put pharmaceutical pricing in the spotlight. Many studies find higher pharmaceutical prices in poor countries than in rich countries (e.g. Bala and Sagoo, 2000), presumably because many poor countries lack a competitive pharmaceutical sector, strong public and private healthcare systems, and effective regulatory controls (Vernon, 2003). Firms with market power may also intentionally raise prices in order to target elite consumers (e.g. Scherer and Watal, 2002). I model monopoly pricing and profit in a market with income disparity in order to emphasize income polarization as a necessary condition for this strategy of pricing to the rich, then discuss preliminary evidence of this polarization effect.

II. Model

Malueg and Schwartz (1994) model the pricing decision of a zero-marginal cost monopolist facing multiple markets. Consumers in different markets share the utility function $V(I, q)$, separable in income

[1] Others focus on the link between median income and prices and find poverty to be generally uncorrelated with prices (e.g. Goodman, 1968).

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(I) and the monopolist's product (q), but have different incomes. Initially, income is uniformly distributed with total income normalized so that the mass of the aggregate market is unity. The inverse demand function for market a is given by

$$p(q) = a(1 - q)$$

where $a \sim U[1-x, 1+x]$ is the market-specific choke price and $x \in [0, 1]$ captures the income disparity between the richest and poorest markets. Markets with high values of a have high income levels.[2] Increasing a thus rotates the demand function clockwise around $(q, p) = (1, 0)$ so that higher values of a imply a steeper slope and lower demand elasticity. A monopolist that cannot price discriminate faces aggregate demand:

$$Q(p) = \frac{1}{2x}\int_b^{1+x}\left(1 - \frac{p}{a}\right), \quad \text{where } b = \max\{p, 1-x\}$$

$$Q(p) = \begin{cases} 1 - \dfrac{p}{2x}\log\left(\dfrac{1+x}{1-x}\right) & \text{if } p \leq 1-x \\ \dfrac{1+x}{2x} - \dfrac{p}{2x}\left(1 + \log\left(\dfrac{1+x}{p}\right)\right) & p \in (1-x, 1+x] \end{cases}$$

For $p < 1-x$, all markets are served, and $Q(p)$ is linear. For $p \in (1-x, 1+x]$, however, some low income markets are priced out of the market, and $Q(p)$ is strictly convex since raising prices above $1-x$ drops high elasticity markets – lowering the elasticity of aggregate demand and steepening its slope. The income disparity parameter x determines where the 'kink' occurs between the linear and the convex portions of $Q(p)$. At x^* such that $Q(1-x^*) = 1/2$, this kink occurs precisely where the marginal revenue associated with the linear portion of $Q(p)$ equals marginal cost (zero). Thus, for $x \leq x^*$ marginal revenue equals zero when $Q(p)$ is linear, and the monopolist maximizes profits by serving all markets. For $x > x^*$ the monopolist serves only some markets.

Monopoly profit maximization yields:

$$p_a(x) = \frac{x}{\log((1+x)/(1-x))},$$
$$\Pi_a(x) = \frac{1}{2}p_a(x) \quad \text{if } x \in [0, x^*]$$

$$p_s(x)\frac{1+x}{y}, \quad \Pi_s(x) = \left(\frac{y-1}{4x}\right)p_s(x)^2 \quad \text{if } x \in (x^*, 1]$$

where p_a (p_s) and Π_a (Π_s) denote the monopoly price and profit when all (some) markets are served, $y = 1 + 2\log(y)$ or $y \approx 3.5128$ and $x^* \equiv (y-1)/(y+1) \approx 0.5568$ (Malueg and Schwartz, 1994). Monopoly price decreases as income disparity grows when $x \in [0, x^*] (p_a'(x) < 0)$ but increases as disparity grows when $x \in (x^*, 1] (p_s'(x) > 0)$. Monopoly profit monotonically decreases with disparity ($\Pi'(x) < 0$ for $x \in [0, 1]$). Holding price constant, profit falls with disparity because increasing disparity causes more markets to be priced out of the aggregate market as their choke prices fall below the (constant) price. The fact that price actually rises with disparity beyond x^* causes yet more markets to be dropped as income disparity increases.

How does increasing disparity affect monopoly pricing and profit differently when the income distribution is polarized instead of uniform? Consider a polarized income distribution consisting of three discrete income classes – upper (U), middle (M) and lower (L) – where the mass (weight) of the market implied by each class is $w_U = w_M = w_L = 1/3$ and choke prices are set at $a_U = 1 + 2x/3$, $a_M = 1$ and $a_L = 1 - 2x/3$. These parameter values introduce income polarization while ensuring that the income distribution is still uniform (albeit discrete) and that total income is still normalized such that mass of aggregate demand is unity. This change in the income distribution sharply distinguishes income polarization, which increases, and income inequality, which decreases by any Lorenz-based ordering (see Fig. 1 in Esteban and Ray, 1994). With this polarized income distribution (Z), the monopolist now faces aggregate demand:

$$Q_{z3}(p) = 1 - \frac{p}{3}\left[1 + \frac{2}{1-(2x/3)^2}\right] \quad p \leq 1 - 2x/3$$
$$Q_{z2}(p) = \frac{2}{3} - \frac{p}{3}\left[1 + \frac{1}{1+2x/3}\right] \quad p \in (1-2x/3, 1)$$
$$Q_{z1}(p) = \frac{1}{3} - \frac{p}{3}\left[\frac{1}{1+2x/3}\right] \quad p > 1$$

where the second subscript on Q indicates the number of income classes served. Profit maximization yields:

$$p_{z3}(x) = \frac{27-12x^2}{54-8x^2}, \quad \Pi_{z3}(x) = \frac{1}{2}p_{z3}(x) \quad \text{if } x \in \left[0, x^{*L}\right]$$
$$p_{z2}(x) = \frac{3+2x}{6+2x}, \quad \Pi_{z2}(x) = \frac{1}{3}p_{z2}(x) \quad \text{if } x \in \left(x^{*L}, x^{*M}\right]$$
$$p_{z1}(x) = \frac{3+2x}{6}, \quad \Pi_{z1}(x) = \frac{1}{6}p_{z1}(x) \quad \text{if } x \in \left[x^{*M}, 1\right]$$

where $x^{*L} \approx 0.776$ and $x^{*M} > 1$ indicate the thresholds at which the lower class is excluded and

[2] Indeed, if $V(I, q) = u(I) + q - (1/2)q^2$ and $u(I) = \ln(I)$, then $a \approx I \sim U[l - x, 1 + x]$ and income disparity between the richest and poorest market is $2x$ (Malueg and Schwartz, 1994).

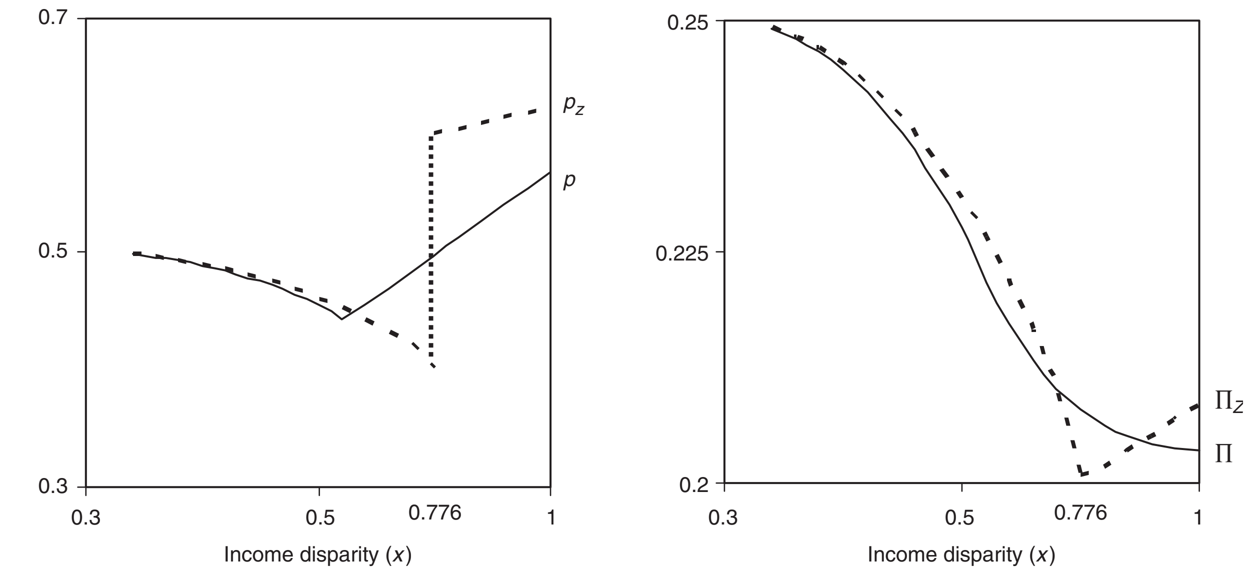

Fig. 1. Monopoly prices (left) and profits (right) for uniform (p, Π) and polarized (p_Z, Π_Z) income distributions

the middle class is excluded, respectively.[3] As income disparity grows, the monopolist still raises its price when, beyond x^{*L}, it becomes profitable to drop low income markets ($p_{Z2}'(x) > 0$). As shown in Fig. 1, however, price now jumps discontinuously at this point. Moreover, with polarized income monopoly profit also increases with x when $x > x^{*L}$ as seen in Fig. 1. This polarization effect – that monopoly price can jump sharply and profit can increase with income disparity when income is polarized – is driven by the zero-mass between discrete markets. Price and income disparity can both increase without dropping markets when there is a zero-mass zone between choke prices. Hence, profit can increase with income polarization.

While polarization in this model takes an extreme form (discretization), continuous multimodal income distributions can produce the same polarization effect. Such multimodal income distributions are common in highly polarized countries such as South Africa, Brazil and Mexico (Sala-i-Martin and Mohapatra, 2002). The density of the distribution between modes need only be sufficiently low that profit from the rich getting richer outweighs market lost from the poor getting poorer. Furthermore, what matters to a particular monopolist is not the income distribution *per se*, but how income maps to demand elasticity. Even a unimodal income distribution might, in practice, produce the polarization effect provided the corresponding distribution of demand elasticities was multimodal.

III. Evidence

The earlier model roughly characterizes the pharmaceutical sector. Pharmaceutical firms operate in many countries with highly polarized income distributions. While income elasticity for pharmaceuticals is often ambiguous (Huttin, 1997, 2000), demand elasticity still normally falls with income. Firms commonly have a degree of market power, due to patents or a lack of domestic competition. Firms often set a different uniform price for each national market because international arbitrage is more difficult than intra-national arbitrage. Given this correspondence between the assumptions of the model and pharmaceutical firms, the model suggests that pharmaceutical prices and profits will be higher in countries with more polarized income distributions.

I test the polarization effect on prices using a panel dataset (Table 1) that includes the average per-dosage ex-manufacture's prices (1998 US$; denoted p) of 20 pharmaceutical molecules in 14 countries,[4] purchasing power parity indices of gross domestic product (GDP) per capita (2000 US$ = 1.00), polarization indices (1994–1997)[5] and Gini indices (1992–1996).[6] Polarization is measured as an index $Z(\alpha)$ where $\alpha \geq 0$

[3] Defined by $\Pi_{Z3}(x^{*L}) = \Pi_{Z2}(x^{*L})$ and $\Pi_{Z2}(x^{*M}) = \Pi_{Z1}(x^{*M})$.
[4] *Source*: Maskus (2001) who uses IMS Health data.
[5] *Source*: Duclos *et al.* (2004).
[6] *Source*: Deninger and Squire (1996).

Table 1. Pharmaceutical prices, GDP and income distribution indices for sample countries

Country	n	Avg. price (1998 US$)	GDP PPP index (2000)	Gini*	Polarization index				
					$\alpha = 0$	$\alpha = 0.25$	$\alpha = 0.50$	$\alpha = 0.75$	$\alpha = 1$
Brazil	19	2.03	0.22	0.60	–	–	–	–	–
Canada	19	1.63	0.78	0.28	0.29	0.23	0.19	0.17	0.15
Czech Republic	17	1.18	0.42	0.28	0.26	0.21	0.19	0.17	0.16
India	7	0.14	0.07	0.32	–	–	–	–	–
Italy	20	1.39	0.70	0.32	0.34	0.26	0.21	0.19	0.16
Japan	8	1.33	0.81	0.35	–	–	–	–	–
Korea	18	1.35	0.45	0.34	–	–	–	–	–
Mexico	18	2.02	0.26	0.50	0.50	0.35	0.28	0.25	0.22
South Africa	19	1.37	0.28	0.62	–	–	–	–	–
Spain	17	1.35	0.55	0.25	–	–	–	–	–
Sweden	16	1.79	0.68	0.32	0.22	0.18	0.17	0.15	0.15
Thailand	17	1.12	0.19	0.52	–	–	–	–	–
UK	20	1.85	0.70	0.32	0.34	0.26	0.22	0.19	0.17
USA	19	2.72	1.00	0.38	0.36	0.27	0.22	0.19	0.16

Note: *Gini estimates are from Deininger and Squire (1996) and $Z(0)$ estimates are from Duclos *et al*. (2004).

Table 2. Regression results for pharmaceutical price model (constant and fixed-effects estimates suppressed)

	Polarization (seven countries)					Gini (14 countries)
	$\alpha = 0$	$\alpha = 0.25$	$\alpha = 0.50$	$\alpha = 0.75$	$\alpha = 1.0$	
No country random effects						
GDP index	1.18* (0.34)	1.22* (0.34)	1.22* (0.35)	1.77* (0.38)	1.6* (0.44)	1.6* (0.30)
Polarization	2.20* (0.97) $p = 0.025$	3.57* (1.62) $p = 0.029$	5.30* (2.35) $p = 0.025$	7.87* (3.24) $p = 0.016$	11.95* (4.33) $p = 0.0063$	
Gini						2.0* (0.60)
R^2	0.85	0.85	0.85	0.85	0.85	0.80
Country random effects						
GDP index	1.17 (0.55)	1.20* (0.54)	1.20 (0.56)	1.70* (0.59)	1.5* (0.66)	1.5* (0.40)
Polarization	2.10 (1.52) $p = 0.17$	3.40 (2.54) $p = 0.18$	5.51 (3.67) $p = 0.17$	7.52 (4.95) $p = 0.13$	11.52* (6.32) $p = 0.069$	
Gini						1.9* (0.80)
N	129	129	129	129	129	235

Note: *Significant at 10% level.

captures the strength of intra-group identity where $Z(0) = \text{Gini}$[7] and $Z'(\alpha) < 0$ (Esteban and Ray, 1994; Duclos *et al*., 2004 for details).

I estimate the effect of polarization and inequality on prices in a country, controlling for average income, molecule fixed-effects and country random-effects using the following models:

$$p_{ij} = \delta_0 + \delta_1 \text{GDP}_j + \delta_z Z_j + \boldsymbol{\theta}'\mathbf{r}_i + u_j + \varepsilon_{ij}$$
$$p_{ij} = \tilde{\delta}_0 + \tilde{\delta}\,\text{GDP}_j + \delta_G \text{Gini}_j + \tilde{\boldsymbol{\theta}}'\mathbf{r}_i + u_j + \varepsilon_{ij}$$

where subscript **i** denotes indexes molecules and j indexes countries, **r** is the vector of molecule dummies, ε is the general error term, and u_j is an error term associated with country j.

Estimation results (Table 2) suggest that income distribution indeed affects prices. Coefficients on GDP are significant and positive – evidence of Ramsey pricing. Coefficients on $Z(\alpha)$ are less precise but larger in magnitude. For $\alpha = 1$, relatively polarized Mexico could expect to pay about \$0.70 more per dose

[7] Since the Gini index and polarization indices in Table 1 were estimated using different data, there is a slight difference between Gini and $Z(0)$ in the data used here.

than less polarized Czech Republic, roughly a 35% premium. High inequality Brazil could expect to pay about \$0.50 more than low inequality India, a 30% premium.

Since $Z'(\alpha) < 0$, coefficients on $Z(\alpha)$ increase in magnitude by construction as α increases. The effect of α on the *statistical significance* of these estimates, however, is meaningful because increasing α amplifies income polarization. Increasing α changes the $Z(\alpha)$ of a distribution relative to another and, can therefore change polarization rankings among countries (Table 1). The polarization effect is statistically stronger when intra-group identity is strong, suggesting that income polarization may more predictably affect prices than income inequality. This evidence, though preliminary, suggests income disparity does affect drug prices and that, as implied by the model, income polarization may explain this effect better than income inequality. More rigorous tests of this polarization effect are of course needed and will become feasible as polarization indices are computed for broader sets of countries.

IV. Conclusion

When income is polarized and disparity is high, a profit-maximizing monopolist that cannot price discriminate necessarily treats poverty mingled with wealth differently than poverty mired in poverty – and the poor are often excluded as a consequence. This note suggests that the poor may be intentionally priced out of the market in order to increase monopoly profits. That polarization can increase monopoly profits was noted by the Commission on Macroeconomics and Health (2001, pp. 87–8): '[pharmaceutical] profits can actually be higher in some low-income markets as the result of a few high-priced sales to a narrow segment of rich customers as opposed to broad-based sales at close-to-production cost' and, consequently, 'pharmaceutical companies are often reluctant to cut their prices in low-income countries.' Since lost profit is the primary opportunity cost of discounting or donating drugs when intra-national market segmentation is unfeasible, the poor in highly polarized countries may have relatively little hope for drug discounts or donations (World Health Organization, 2001; Friedman *et al.*, 2003). In such countries, 'the existence of a few elite cadres affects . . . schemes intended for the poor majority' (Friedman *et al.*, 2003, p. 342).

The inability to segment intra-national markets introduces this polarization burden, which reinforces the social value of increasing the resolution at which market segmentation occurs (Varian, 1985). In pharmaceuticals, the General Council of the World Trade Organization requires suppliers to use product colour or shape as a segmentation technique to distinguish essential medicines exported under compulsory license from otherwise identical pharmaceuticals. In agriculture, the Rockefeller Foundation and others have explored humanitarian use licensing as a potentially promising, if untested, segmentation technique (Byerlee and Fischer, 2002; Lybbert, 2002). The value of these segmentation techniques is especially pronounced in agriculture and pharmaceuticals because the marginal cost of production is low enough that proprietors are often willing to donate or offer deep discounts on these technologies *provided* they can continue to earn a return on R&D investment in more lucrative markets.

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