Price sensitive prescribers

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When prescribers are not price sensitive, prescriptions segment the duopoly market and the unique dominant strategy equilibrium has both firms setting the monopoly price. When some prescribers are price sensitive, manufacturers use mixed strategies but still earn positive expected profit.

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1. Introduction

Many explanations have been offered for why pharmaceutical prices are so high, ranging from demand management to the ability to recover development costs.1 However, a simpler explanation is that the individual paying for the good is not the one who decides which good, or how much of it, to purchase. In particular, a physician prescribes a fixed amount of a single medication, and the patient’s only choice is to purchase that drug or go without treatment. Even if there are two (or more) available products that are close substitutes, the physician prescribes only one, and this limits the customer’s choice.

The same situation arises in textbook markets. The instructor adopts a specific book for the course, and students choose either to purchase it or not. There may be, and often are, close substitutes in the market, but students have no way of telling whether one text will suffice as a substitute for the assigned one, and so students do not purchase competing texts. And, as students often complain, textbook prices tend to be high.

This paper explores what happens when some prescribers, either physicians for medicine or instructors for textbooks, are price sensitive. Such an analysis is germane because, as Bell and Badolato (2008) report, in 2007 legislatures in 27 states considered more than 85 bills dealing with textbook affordability. By the end of the year ten of the states had enacted 15 laws. In addition, Iizuka (2007) finds evidence that Japanese physicians care about saving patients money, especially elderly patients, although Windmeijer et al. (2006) contend that physicians tend to be price insensitive. Still, the question remains whether the existence of some price sensitive prescribers is enough to bring prices down.

2. The environment

The market consists of two homogeneous goods, labeled 1 and 2.2 Each good can be produced at constant unit cost $c$. The two firms that produce the goods compete on price.

There is a unit mass of risk neutral consumers, indexed by the interval [0, 1], each demanding either one or zero units of the good depending on events. When a consumer demands one unit of the good, her value is also in the unit interval, so we can use a consumer’s index as her (conditional) value. Consider a typical consumer $\nu$. With probability $\eta$ an event $E$ (with complement $E^c$) occurs generating a willingness-to-pay of $\nu \in [0, 1]$ for a single unit of the good, and with probability $1 - \eta$ the event $E$ does not occur and willingness to pay is zero. The event $E$ can be thought of as the onset of an illness, in which case the consumer has positive value for a treatment. The probability parameter $\eta$ is common to all consumers, and the occurrence of the event $E$ is independent across consumers. The distribution of the conditional willingness-to-pay parameter $\nu$ is $f(\nu|E)$ with density $f(\nu|E)$, and no one is willing to pay more than 1 for a unit of the good. Note that

2 These two goods are best thought of as two competing branded drugs, or two competing generic drugs. Competition between a branded and a generic drug would use a different model.
the distribution $F(\nu|E^\nu)$ is the degenerate distribution placing probability one on the outcome $\nu=0$.

A fraction $\alpha$ of prescribers are price sensitive, prescribing whichever of the two goods has the lower price, and prescribing them with equal likelihood if the prices are the same. The fraction $1-\alpha$ of price-insensitive prescribers assign the goods randomly with equal likelihood. Under these conditions the demand for good $i$ is given by

$$q_i(p_i, p_j) = \begin{cases} (1-\alpha)p_i - F(p_i|E) / 2 & p_i > p_j \\ \alpha p_i - F(p_i|E) / 2 & p_i = p_j < 1 \\ (1+\alpha)p_i - F(p_i|E) / 2 & p_i < p_j < 1 \end{cases}$$

(1)

It is useful to identify the monopoly price for this market. The monopolist's problem is

$$\max_{p} (p-c)\eta(1-F(p|E)).$$

(2)

It is assumed throughout the paper that $(p-c)\{1-F(p|E)\}$ is concave with a unique interior maximum denoted $n^*$, with the corresponding monopoly price denoted $p^m$.

3. Prescription pricing

When every prescriber is price sensitive, so that $\alpha = 1$, the demand function (1) reduces to the familiar demand function for a Bertrand duopolist, and the resulting equilibrium has marginal cost pricing. When $\alpha = 0$, so that no prescriber is price sensitive, the demand function reduces to

$$q_i(p_i, p_j) = \frac{1}{2}\eta(1-F(p_i|E)).$$

(3)

This segments the market, and firm $i$'s demand is independent of $j$'s price, making each firm a monopoly in its own market. The following result follows immediately.

**Proposition 1.** When no prescribers are price sensitive, the unique dominant strategy equilibrium has both firms setting the monopoly price.

When $0<\alpha<1$, there is no symmetric equilibrium in pure strategies. To see why, suppose that $p_1 = p_2 = p$. Then both firms face demand $\eta(1-F(p_i|E))$ and earn profit $(p-c)\eta(1-F(p_i|E))$. Firm $i$'s profit function can then be written

$$\eta_i(p_i) = \begin{cases} (p_i - c)(1-\alpha)p_i - F(p_i|E) / 2 & p_i > p_j \\ (p_i - c)(\alpha)p_i - F(p_i|E) / 2 & p_i = p_j < 1 \\ (p_i - c)(1+\alpha)p_i - F(p_i|E) / 2 & p_i < p_j < 1 \end{cases}$$

(4)

From (4) it is clear that as long as $p>c$, firm $i$ has an incentive to reduce its price below the candidate-equilibrium price by a small amount, thereby increasing its profit by (almost) a factor of $(1+\alpha)$.

The next proposition describes several features of the symmetric mixed strategy equilibrium.

**Proposition 2.** The symmetric mixed strategy equilibrium is a probability distribution $\sigma(p)$ with the following features:

(a) $\sigma$ has no mass points;
(b) The support of $\sigma$ has no gaps;
(c) The upper endpoint of the support is the monopoly price $p^m$; and
(d) For each price in the support of $\sigma$, expected profit is $\frac{1}{2}(1-\alpha)p^m$.

**Proof.** (a) Suppose to the contrary that $\sigma$ places mass $\nu_0$ on price $p_0$. If firm $1$ moves this mass infinitesimally lower, it increases expected profit by $\alpha \nu_0(p_0-p_1)n(1-F(p_1|E))/2$, which is strictly positive. Consequently there is no equilibrium in which $\sigma$ has mass points.

(b) First, $\sigma(p) = 1$ for all $p \geq p^m$. To prove this, suppose to the contrary that $\sigma(p)<1$ for some $p>p^m$. If firm $1$ changes its mixing strategy to move all of the mass on the interval $(p^m, \infty)$ to the point $p^m$ its profit increases because (i) the monopoly price is profit maximizing, and (ii) the probability that $p_1 < p^m$ increases. Thus, $\sigma$ cannot be an equilibrium if it places mass above the monopoly price $p^m$.

Second, the support of $\sigma$ has no gaps. Suppose, to the contrary, that the support had a gap over the interval $(p_0, p_1)$, and consider the price $p \in (p_0, p_1)$. A firm that charges price $p$ has the higher of the two prices as often as a firm that charges according to $\sigma$, and it has the lower of the two prices as often as a firm that charges according to $\sigma$. However, since $p_0 < \sigma(p) < p_1$, charging $p$ generates more expected profit than charging $p_0$, and since all prices in the support of $\sigma$ must generate the same expected profit, firms can earn strictly higher profit by charging $p$ with certainty. Therefore there can be no gaps.

(c) Suppose to the contrary that $\sigma(p_0) = 1$ for some $p_0<p^m$. If a firm charges $p^m$ instead of $p_0$ it is no less likely to have the lower of the two prices, but it earns strictly more expected profit. Consequently, the support of $\sigma$ must contain $p^m$.

(d) By the nature of mixed strategy equilibria, every price in the support of $\sigma$ must generate the same expected profit. In particular, when the firm charges price $p^m$ it has the higher of the two prices with probability 1, in which case its profit is $\frac{1}{2}(1-\alpha)p^m$ according to (4).

Proposition 2 describes the Nash equilibrium mixed strategy distribution without identifying it. Part (a) of the proposition says that the mixed strategy has no mass points, because if it did place positive mass on one price, both firms would have an incentive to move that mass to a slightly lower price and take more of the market with positive probability. Part (b) says that the mixing distribution has no gaps, because if it did both firms would have an incentive to move mass to some price inside of the gap. Part (c) says that the support of the mixing distribution contains the monopoly price. Part (d) says that every price in the support of the mixing distribution generates the same expected profit, and furthermore that expected profit is the profit a firm would expect to earn by serving only its share of the price-insensitive prescribers.

This last result implies that the support of the mixing distribution must be bounded away from marginal cost. Consequently only prices strictly higher than marginal cost can be charged. Because the expected profit is below $p^m$, the existence of some price sensitive prescribers partially mitigates high pricing of prescribed goods, but since the support of $\sigma$ is bounded away from $c$, having some price sensitive prescribers is not sufficient to fully mitigate the impact of prescriptions.

From Proposition 2 it is possible to compute the mixed strategy distribution $\sigma(p)$. A firm charging price $p$ earns expected profit

$$E(p) = \sigma(p)(1-\alpha) + (1-\sigma(p))(1+\alpha)(p-c)n(1-F(p|E))/2.$$

By part (d) of the proposition this expected profit must equal

$$\left(1-\alpha\right)p^m/2 = (1-\alpha)(p^m-c)\eta(1-F(p|E))/2.$$

Equating these two expressions and solving yields

$$\sigma(p) = \frac{1}{2\alpha}\left[1 + \alpha - (1-\alpha)(p^m-c)/(p-c)(1-F(p|E))\right].$$

The term

$$\frac{(p^m-c)(1-F(p^m|E))}{(p-c)(1-F(p|E))}$$

is the ratio of monopoly profit when price is $p^m$ to monopoly profit when price is $p \leq p^m$, which is decreasing in $p<p^m$ by the assumption
that \((p-c)[1-F(p|E)]\) is concave in \(p\). Because of this, \(\sigma\) is increasing in \(p\) when \(p<p^m\). It is equal to one when \(p\geq p^m\) and equal to zero when \(p\leq p_L\) defined implicitly by

\[
(1 + \alpha_f)[p_l - c] \eta [1 - F(p_L | E)] = (1 - \alpha_f)[p^m - c] \eta [1 - F(p^m | E)].
\]

(5)

where the right-hand side is simply \(\frac{1}{2}(1 - \alpha_f)p^m\).

The upper endpoint of the mixed strategy distribution \(\sigma\) remains fixed at the monopoly price \(p^m\) as the fraction \(\alpha_f\) of price sensitive prescribers increases. The next proposition concerns how expected profit changes when the price sensitive fraction grows.

**Proposition 3.** When a larger fraction of prescribers is price sensitive, the right endpoint of the mixing distribution remains fixed at \(p^m\), but both expected profit and the lower endpoint of the mixing distribution decline. Furthermore, as the fraction converges to one, expected profit converges to zero and the lower endpoint of the mixing distribution converges to marginal cost.

**Proof.** The behavior of the right endpoint of the mixing distribution follows directly from condition (c) of Proposition 2. For expected profit, by condition (d) of Proposition 2 expected profit is equal to \(\frac{1}{2}(1 - \alpha_f)p^m\), which is a declining function of \(\alpha_f\) which converges to zero as \(\alpha_f \rightarrow 1\).

As for the lower endpoint of the mixing distribution, implicitly differentiating (5) with respect to \(\alpha_f\) and solving yields

\[
dp_f = \frac{[p_l - c][1 - F(p_L | E)] + (p^m - c)[1 - F(p^m | E)]}{(1 + \alpha_f)[1 - F(p_L | E) - (p_l - c)f(p_L)]}.
\]

(6)

The numerator of (6) is nonnegative, and the denominator is nonnegative if \(1 - F(p_L | E) - (p_l - c)f(p_L) > 0\). Note, however, that when \(p(p) = (p - c)[1 - F(p | E)]\), we have

\[\pi'(p) = 1 - F(p | E) - (p - c)f(p)\]

and we know that \(p(p)\) is maximized at \(p = p^m > p_L\). Consequently \(\pi'(p_L) \geq 0\), and \(dp_f/\alpha_f \leq 0\).

Both sides of (5) are continuous in \(\alpha_f\), and the right-hand side is zero when \(\alpha_f = 1\). Consequently, we have

\[
\lim_{\alpha_f \rightarrow 1}(p_L(\alpha) - c)(1 + \alpha_f)[1 - F(p_L(\alpha) | E)] = 0
\]

which implies that

\[
\lim_{\alpha_f \rightarrow 1}p_L(\alpha) = c.
\]

\(\square\)

Proposition 3 provides two senses in which increases in the fraction of price sensitive prescribers leads to a (stochastic) price reduction: the expected profit of the firms falls and firms place probability mass on prices closer to marginal cost.

**4. Conclusions**

This paper provides an explanation for why prescription drug prices are so high: drugs require prescriptions, which segment the market and allow drug manufacturers to charge the monopoly price. The major policy issue is what to do about the high prices. If some prescribers become price sensitive, a mixed strategy equilibrium ensues, with firms placing probability on prices bounded away from marginal cost and extending all the way to the monopoly price. Furthermore, firms still earn positive expected profit. As more prescribers become price sensitive, though, the support of the mixing distribution extends closer to marginal cost and expected profit converges to zero. In these senses, then, convincing prescribers to become price sensitive leads to lower prices and lower manufacturer profit.

A number of state laws directed at high textbook prices seem to recognize this result. Many of them, including those in California, Maryland, and Tennessee, require evidence that instructors are aware of textbook prices. It remains to be seen whether these policies succeed in making some instructors price sensitive and whether textbook prices come down as a result.

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**References**


