Pricing Policy Choice by Internet Retailers

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Abstract

Internet sellers must decide how customers pay shipping charges. Typically, these sellers choose between “uniform pricing,” where the firm delivers to any customer at a fixed delivery charge, or “mill pricing,” where the firm bills the customer a distance-related shipping charge. This paper studies price competition between an internet seller and local retailers, and the internet seller’s choice of pricing policy. It is found that for low customer willingness to pay, mill pricing is favored but as willingness to pay rises, uniform pricing becomes more attractive. These results are generalized showing that larger markets, higher transportation rates, higher unit production cost, and greater competition between retailers all increase profit under mill pricing relative to uniform pricing (and vice versa). Cost asymmetries that favor the internet seller will tend to induce uniform rather than mill pricing. Some empirical data on retail and web retail sales that are consistent with these results are presented.

1. Introduction

Internet sales have become an important component of retail sales. For more than a century, mail-order sales offered shop-at-home convenience for geographically isolated or busy consumers. In the past 15 years, this trend has continued with the advent of internet shopping. In addition to time savings, internet shopping provide competitive alternatives to local retailers’ prices and product assortment.

This paper studies price competition between internet sellers and local retailers (often called “bricks and mortar” stores) which need to be transported by or to the customer. I study how such competition affects the internet sellers’ choice of how to charge for delivery. In this analysis I ignore differentiators between internet sellers and local retailers aside from transit and convenience cost of travel. Thus, I do not consider other possible differences such as service quality or product assortment. In short, the focus is on competition between internet sellers and local retailers for similar goods.

An important aspect of competition between internet sellers and retailers is the issue of competitive pricing, and the related issue of how customers pay shipping charges. Traditionally, internet sellers chose between two pricing policies: either “uniform spatial pricing,” where the firm charges the same delivery charge (and vice versa). Cost asymmetries that favor the internet seller will tend to induce uniform rather than mill pricing. Some empirical data on retail and web retail sales that are consistent with these results are presented.

In contrast to uniform spatial pricing are other pricing regimes such as mill pricing (sometimes called f.o.b. pricing where the customer pays the freight cost. In this paper I study and contrast the strategic choice of uniform pricing versus mill pricing for internet seller sellers. I explicitly neglect other patterns of spatial delivered pricing as discriminatory spatial pricing patterns have been declared illegal under the Robinson-Patman Act (and related laws in Europe).

This paper contributes to the literature by developing an analytic model that can explain why some internet sellers use uniform pricing and others do not. Intuition behind the model shows that there are two countervailing factors, one of which tends to favor mill pricing and another that can favor uniform pricing.

The first factor is that as price rises at a market point eventually demand will fall to zero. This demand truncation causes the demand function to be convex, which I show causes mill pricing to generate higher profit than uniform pricing, all other things
being equal. I refer to this as the demand truncation effect.

The second factor is caused by the existence of distant competing retail firms. I assume that customers buy from the firm offering the lowest delivered price. For linear demand functions and any mill price set by the internet seller, there is an associated uniform price that earns the internet seller identical total profit on the market points where the mill price generates positive demand. But at this uniform price, the internet seller always penetrates a larger market area. If the mill price is high enough, then the new market area captured creates additional profit for the internet seller. However, if the mill price is low enough, then the new market area captured by the corresponding uniform price is unprofitable and reduces profit. I call this the market penetration effect.

Thus, demand truncation and market penetration effects can create contradictory forces. How they resolve is explained in this paper using analytical results.

1.1. Literature review

There is a small but significant literature on uniform pricing in the economics literature. Several authors present conjectures about why firms use uniform pricing. Among them is Norman [1] and Cheung and Wang [2], who hypothesize that uniform pricing occurs because of low customer billing cost. However, this hypothesis does not explain why some firms find billing for shipping “complex” and others find individual billing simple enough to execute. For example, why does Lands’ End set uniform prices while PartsAmerica uses mill pricing when the latter is a much smaller firm with (presumably) higher billing cost?

To date the strongest argument for uniform pricing is offered by Smithies [3]. (Stevens and Rydell [4] reproduce Smithies’ results and argue that a profit maximizing selling firm may limit its choice of pricing policy to either uniform pricing or mill pricing, for the legal reasons cited above.) That paper assumes a linear bounded market with uniformly distributed customers having elastic demand for a single good, and a single monopolist with a fixed location selling this good. Smithies shows that convexity or concavity of each customer’s demand function makes uniform or mill pricing more profitable. He states (page 64, Proposition 3):

“If the monopolist is considering the alternatives of f.o.b. selling and of a uniform delivered price, and is subject to constant marginal cost, he will adopt the former if the demand curve is convex, and the latter if it is concave. It the demand curve is linear, it is indifferent to him which of the two policies he adopts.”

(Smithies refers to a function that is convex (concave) upwards as convex (concave). I altered his statement to accord with the modern definition of a convex (concave) function.) These results must be qualified by the condition that all customers in the market are served with positive demand. (Smithies did not make this explicit.) Also, the proposition can be generalized to non-uniform distributions of customers. See Lederer [5].

Smithies’ work yields an immediate insight. When demand is linear but demand is not allowed to fall to zero, say, assuming local demand function, \( D(p) = [a-p]^+ \). Smithies’ results predict that mill pricing will yield higher profit because the demand function is now convex. This is what I called the demand truncation effect in the last subsection.

There is scant empirical work on the use of uniform pricing. Most relevant to web retailing, Dinlersoz and Li [6] report that internet booksellers almost all use uniform pricing. Less relevant due to focus on industrial markets are two papers: Philips [7] presents examples of uniform pricing in Europe in the cement and plasterboard industries, and Greenhut [8] shows that in industrial markets uniform pricing is widely used.

The rest of the paper is organized as follows. Section 2 presents the basic model of this paper. Section 3 studies the problem when retailers do not react in price to internet seller price changes. Section 4 closes the paper with empirical observations and generalizations implied by the analysis.

2. Pricing for internet seller delivery

I study price competition between a internet seller and retailers located some distance away who supply a market with a single good. Customers travel to the retailer(s) but use the shipping services provided by a internet seller when buying via internet seller. The internet seller must decide whether to offer a flat delivery charge bundled into the purchase price or a separate distance-related charge. Thus, I allow the internet seller to choose either uniform or mill prices. The retailers serve local customers that provide their own transport, and thus implicitly use mill pricing. I seek to study competitive price policy choice by the internet sellers and retailers.
The set-up I choose is that of two retailers located on the ends of the unit interval $[0,1]$. The retailer at the origin is called “Retailer 1,” and the other at $x=1$ is called “Retailer 2.” The internet seller is located at the center of the line at $x=0.5$. All locations will be held fixed. For simplicity, the retailers’ and the internet seller’s production cost is zero. The effect of this assumption is to abstract the product’s price away, and focus on the delivery charges. Thus, the model can compare price policy choice for the same category of good, independent of the actual non-zero production cost.

The per unit per distance transport cost for customers (to each retailer) is $t$ as is the transport cost of the internet seller from its site to its customers. I discuss the effect of making these two transport rates different in the last section of the paper. Although I have chosen to describe the market with two retailers and one internet seller, the model is easily adapted to the case of one retailer. I have chosen two separated retailers to capture the physical aspect of transportation. That is, there are spatially separated retailers and an internet seller distant from both. However, results with one retailer would be identical.

Customers have constant density on the interval with each having an identical demand function

$$D(p) = [a-p]^+.$$  

By using a demand function in this simple form, I abstract away all other market characteristics besides parameter $a$ and the market price plus transportation cost (as combined in mill prices), or market price plus customer convenience cost (in uniform pricing as customers must find their own way to the retailer and this involves a cost). I may identify $a$ as the ratio of the market size to demand slope, and also as a customer’s maximum willingness to pay, as no customer will pay more than $a$ for a unit of the good.

The retailers and the internet seller engage in price competition. The retailers choose a mill price, while the internet seller choose a pricing policy and a price under that policy.

Under a uniform policy by the internet seller company, if Retailer 1 sets a price, $p_{U1}$, (read the retailer sets its mill price against the internet seller’s uniform price), the internet seller prices at $p_U$, then the market boundary between retailer and internet seller is just $x_1 = .25 + \left(\frac{p_U - p_{U1}}{2t}\right)$, if $x_1$ is within $[0,0.5]$, and if not, then the market boundary is at the appropriate closest boundary points on that interval. (For Retailer 2, the boundary is $x_2 = .75 - \left(\frac{p_U - p_{U1}}{2t}\right)$). Assuming symmetry in the retailers’ prices the internet seller and retailers’ profits under uniform pricing are

$$\Pi_U = 2\max\{a-p_U\} \int_{\max\{0,\frac{a-p_U}{t}\}}^{\min\{\frac{a-p_U}{t},1\}} (p_U - t(5-x))dx$$

(2.2)

$$\Pi_{U1} = \max\{0,(a-(p_{U1}+tx))\} dx.$$

All customers will be served with positive quantities when the lowest price in the market at every point is less than the customers’ maximum willingness to pay, $a$.

Under mill pricing by the internet seller, if Retailers 1 and 2 set a price $p_M$ and the internet seller prices at $p_M$, then the market boundary between Retailer 1 and the internet seller is $x_1 = .25 + \left(\frac{p_M - p_M}{2t}\right)$ (or the closest boundary point if $x_1$ is outside $[0,0.5]$). (For Retailer 2, the boundary is $x_2 = I-x_1$).

The internet seller and retailers’ profits (again assuming symmetry of retailers’ prices) are

$$\Pi_U = 2p_M \int_{\max\{0,\frac{a-p_M}{t}\}}^{\min\{\frac{a-p_M}{t},1\}} (a-(p_M - t(5-x)))dx$$

(2.3)

Simplification of analysis comes by noting:

**Lemma 2.1.** Profit functions (2.2) and (2.3) are homothetic of degree 2 when scaling the vectors: $(a,t,p_U,p_{U1})$, and $(a,t,p_M,p_M)$, respectively.

Profit functions in (2.2) and (2.3) can thus be rewritten:

$$\Pi_t(a,t,p_U,p_{U1}) = t^2\Pi_t(a,1,\frac{p_U}{t},\frac{p_{U1}}{t}), t^3\Pi_t(a,t,p_{U1},p_U) = t^3\Pi_t(a,1,\frac{p_{U1}}{t},\frac{p_{U}}{t})$$

and

$$\Pi_t(a,t,p_M,p_M) = t^4\Pi_t(a,1,\frac{p_M}{t},\frac{p_{M}}{t}), t^3\Pi_t(a,t,p_M,p_M) = t^3\Pi_t(a,1,\frac{p_{M}}{t},\frac{p_{M}}{t})$$

(2.4a)

$$\Pi_t(a,t,p_U,p_{U1}) = t^2\Pi_t(a,1,\frac{p_{U1}}{t},\frac{p_{U}}{t}), t^3\Pi_t(a,t,p_{U1},p_U) = t^3\Pi_t(a,1,\frac{p_{U1}}{t},\frac{p_{U}}{t})$$

(2.4b)

When $t\neq1$, the profit function can be transformed into an equivalent profit function with $t=1$ by rescaling by division by $t$ of $a$ and the prices.

Thus, if the functions:

$$\Pi_t(a,1,p_U,p_{U1}),\Pi_t(a,1,p_M,p_{M})$$

$$\Pi_t(a,1,p_M,p_{M}), \text{ and } \Pi_t(a,1,p_{U1},p_U)$$

are known, profit can be computed for any case where $t\neq1$. I therefore assume for the remainder that $t=1$.

It also should be pointed out that my results apply to all linear demand functions $d(p) = \alpha - \beta p$.

This demand function is homothetic of degree 1 when
scaling variables \((\alpha, \beta)\). Thus, profit will be homothetic of degree 1 with the same scaling. Scaling enables transformation of any linear demand function into the canonical form: 
\[
D(p) = [a-p]^+.
\]

3. **Competition between the Internet Seller and Retailers**

For simplicity, it is assumed that both retailers do not adjust prices in response to the internet seller’s choice. Assumption of fixed retailers’ prices may be reasonable in large, very competitive retail markets. For example, in a perfectly competitive market, competing firms at the retailers’ sites are price-takers and set price equal to marginal cost, which is zero. If the retailers’ do not react, Figs. 1a and 1b demonstrate the basic economics of price policy choice for a internet seller.

Suppose the internet seller chooses its profit maximizing mill price, \(p_M\), when confronted by retailers who price at \(p_r > 0\). The internet seller serves region \([x,1-x]\). See Fig. 1a. I assume that parameter \(a\) is large enough so the internet seller’s delivered price is less than each customer’s willingness to pay \((a)\) for all customers in \([x,1-x]\), so that the demand truncation effect does not hold on the interval. Thus, all customers in the interval purchase positive quantities. Following Smithies’ Proposition 3 discussed earlier: if the internet seller sets a uniform price that would be optimal for the market area \([x,1-x]\), its aggregate profit for the interval is the same as when it sets mill prices, but it also serves additional customers: those from \([y,x]\) and \([1-x,1-y]\). Proposition 3.1 shows that for sufficiently large \(a\), the uniform pricing firm earns positive contribution on this additional market territory. In the absence of demand truncation on \([x,1-x]\) and the profitability of market penetration, uniform pricing is seen to be the profit maximizing choice by the internet seller.

But what if parameter \(a\) is relatively small? In this case, a uniform pricing firm may find that the demand truncation effect causes mill prices to generate higher profit on the interval \([x,1-x]\), or the market penetration effect causes extra market gained with uniform pricing to generate negative contribution. Either or both effects can cause mill pricing to generate higher profit. Fig. 1b shows such a situation where the internet seller earns positive profits in the interval \([z,1-z]\) and negative profit elsewhere. Proposition 3.1 shows that mill pricing will generate higher profit than uniform pricing if parameter \(a\) is small enough. What sufficiently “small” and “large” mean is made precise in Proposition 3.1, which follows next. In many situations the demand truncation effect (favoring mill pricing) and the market penetration effect (favoring uniform pricing) can conflict with the dominating effect determining whether uniform or mill pricing generates higher profits.

In the following, I assume that the retailers have set a fixed mill price equal to zero: \(p_r = 0\). The internet seller chooses its pricing policy and its price to maximize its profit. I find the value of parameter \(a\), where the market penetration effect is favorable enough (to uniform profit) to overcome any demand truncation effect (favorable to mill profit) so that uniform pricing yields superior profit. It is explicitly shown that these results generalize to cases where \(p_r > 0\).

**Proposition 3.1.** A price policy optimum for the internet seller exists with fixed retailer price \(p_r = 0\). Optimum uniform and mill prices are strictly monotone increasing in parameter \(a\) as long as price is lower than \(a\). In addition.

- a. For all \(a \leq .1666\) a uniform pricing internet seller earns zero profit.
- b. For all \(a \leq .3384\), mill pricing is the optimum pricing policy for the internet seller.
- c. For all \(a \geq .3384\), uniform pricing is the optimum pricing policy for the internet seller.
- d. At optimum, the internet seller earns positive profits.
- e. These results generalize for any fixed retailer price with different breakpoints.

**Proof.** I show this result for \(p_r = 0\) by algebraic manipulation. Strict monotonicity of prices with respect to \(a\) can be explicitly shown. The system of equations is similarly solved for other fixed retailer prices. QED

4. **Generalizations and empirical observations**

The results of this paper are driven by the insight that the demand truncation effect favors mill pricing, and the market penetration effect can favor uniform pricing.

This simple observation combined with the results of the last section suggests several generalizations. I briefly discuss implications for different market radii, unit production costs, transportation rates, asymmetries in these costs, and degrees of market competition.
Suppose the market absolute length is greater than a unit distance. I suppose that the retailers remain at the endpoints and the internet seller in the middle of the segment. In this case, all things being equal, the larger the market segment, the more likely that demand truncation occurs, and that the additional market penetrated by the internet seller is unprofitable. This tends to favor mill pricing. Likewise, “shorter” markets favor uniform pricing.

Implications of production and transport cost can be made. Eq.s (2.4) indicates that the ratio of $a/t$ is the relevant parameter to consider (rather than $a$) when the transportation rate is not 1. Thus, the preceding analytics show that as transportation rate rises, mill pricing becomes more likely. More intuitively, when $t$ is small, then demand truncation becomes less important, and the market penetration more important. Thus, lower transportation rates favor uniform pricing. Similarly, if marginal cost of production is not zero but positive: higher marginal cost favors mill pricing because higher marginal cost will raise optimum prices, and demand truncation becomes more important. Thus, I see that both sufficiently low transport and sufficiently low production costs favor uniform pricing by the internet seller.

Production and transportation cost asymmetries also have an effect on price policy choice. If retail customers’ (self) transportation rate rises, then the retailers’ delivered price in equilibrium with either mill or uniform internet seller pricing will rise. Following the argument in Figs. 1a,b, the internet seller’s profit with uniform pricing compared to mill pricing becomes relatively greater as the retailers’ price rises. Thus, uniform pricing becomes relatively more attractive. Similarly, suppose the retailers’ marginal cost rises. This induces the retailers’ delivered prices to rise in equilibrium. Following the argument in Figs. 1a and 1b, the internet seller’s profit with uniform pricing becomes relatively greater than with mill pricing as the retailers’ marginal cost rises. In general, cost asymmetries that favor the internet seller will tend to make the internet seller more likely to adopt uniform pricing.

It might be suggested that other factors can explain the use of uniform pricing. It is recognized that customer accounting and billing cost may be lower with uniform pricing. However, that insight does not negate our current result that ties relative willingness to pay with pricing policy choice.

Note too, our result about the effect of demand truncation on pricing policy choice is general to other demand functions. As price rises, there becomes a point in any elastic demand function that demand goes to zero, or goes to zero asymptotically. In either case, demand truncation occurs and can favor mill pricing.

Gross operating margin is the ratio of operating profits divided by revenue. High gross operating margin implies a high willingness to pay by the customer. Table 1 shows gross operating margins for retailers in a number of specialties in 2006 as reported by the U.S. Census Bureau. The table shows margins of several types of bricks-and-mortar firms, as well as an estimated margin for combined electronic (that is, internet) and internet seller retail businesses. The margins range from 19.1% to 51.9% with reported standard error 0.2%. Retail specialties with the highest margins are clothing goods and furniture! Not surprisingly, clothing-related internet retailers most often use uniform pricing, a fact that is consistent with the observation that high gross operating margins would be expected to favor uniform pricing over mill pricing. Note too, that the gross operating margin for internet sellers is reported to be 40% which is higher than the overall unweighted average, 35.8%. The high margin for the internet/internet seller category is consistent with the use of uniform pricing by internet sellers.

A consistent but still surprising observation is that internet sellers of furniture most often use uniform pricing! There are many examples of this including www.csnsofas.com, www.greatpricedfurniture.com, and www.efurnitureshowroom.com. Despite the high absolute transport cost of furniture, the high customer willingness to pay allows furniture internet retailers to use uniform pricing.

On the other hand, internet sellers that use mill pricing, such as Bikesmart (bicycle parts), PartsAmerica (spare parts for appliances), and Vegetarian Store (specialty foods), all sell in categories with lower margins.

Finally, severe competition between the retailers can affect policy choice. If multiple retailers compete in markets and the situation approximates perfect competition, then retailers will price at or near marginal cost. Pricing at marginal cost will cause a mill pricing internet seller to lower its price compared to the case where the retailer prices above marginal cost. If uniform prices are used, market penetration effects will generate losses. The net effect is that mill pricing will be more attractive to the internet seller. In general, if it is assumed that local retail prices fall as a function of degree of competition (a reasonable assumption that holds in most situations), it can be concluded that more competitive markets encourage internet sellers to use mill pricing. Analysis of the situation where the retailers adjust their process in reaction to that of the internet seller are presented in Lederer[5]. The results are broadly consistent with those of this paper.
Figure 1a. Uniform pricing yields higher profit than mill pricing if parameter $a$ is high enough.

Suppose the internet seller faced by retailer price $p_r$ sets its profit maximizing mill price, $p_{M*}$. The internet seller chooses its uniform price equal to $p_U = p_{M*} + \bar{t}$, where $\bar{t}$ is the average transportation cost in the interval $[x, 1-x]$. High value of $a$ causes prices and margins to be relatively high, which is shown in the large gap between prices and transport cost. We assume that under mill prices all customers in the interval $[x, 1-x]$ are served with positive quantity of good. Under this assumption, Smithies [3] shows that profit restricted to the interval $[x, 1-x]$ using the uniform price and the mill price are identical. When the uniform pricing firm earns positive contribution on the intervals $[y, x]$ and $[1-x, 1-y]$, uniform pricing yields greater total profits than mill. We will show in Theorem 3.1 that the optimum mill price is strictly monotone in parameter $a$ and the uniform pricing firm earns positive contribution on the intervals $[y, x]$ and $[1-x, 1-y]$ when parameter $a$ is high enough.
Fig. 1b. Mill pricing yields higher profit than uniform pricing if parameter $a$ is low enough. For some small value of $a$, the internet seller’s profit maximizing uniform price against retailers’ price $p_r$ is $p^*_U$. Low value of $a$ causes prices and margins to be relatively small, which is shown in the small distance between prices and transport cost. Note that outside of the interval $[z,1-z]$, uniform pricing yields negative profit. Now define a mill price: $p'_M = p^*_U - \bar{t}$ where $\bar{t}$ is the average transportation cost in the interval $(z,1-z)$. As shown by Smithies [3], the profits for this mill price and the optimal uniform price restricted within the interval $[z,1-z]$ are identical. But it is clear that outside this interval, the mill pricing firm earns additional contribution, but a uniform pricing firm loses contribution.

<table>
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<tr>
<th>Kind of business</th>
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<tr>
<td>Men's clothing stores</td>
<td>51.9</td>
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<tr>
<td>Shoe stores</td>
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<tr>
<td>Women's clothing stores</td>
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<tr>
<td>Furniture and home furnishings stores</td>
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<tr>
<td>Automotive parts, access., and tire stores</td>
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<tr>
<td>Family clothing stores</td>
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<tr>
<td>Electronic shopping and mail-order houses</td>
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<tr>
<td>Sporting goods, hobby, book, and music stores</td>
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<tr>
<td>Total (excl. motor vehicle and parts dealers)</td>
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