Why 99 Cents?*

Oz Shy

University of Haifa, and
Stockholm School of Economics

E-mail: ozshy@econ.haifa.ac.il
Homepage: http://econ.haifa.ac.il/∼ozshy/

Mailing address:
Department of Economics
University of Haifa
Mount Carmel
31905 Haifa, ISRAEL

Revised, June 19, 2000

Abstract

I suggest a strategic explanation for why so many products and services are priced to end in ninety nine! I demonstrate that when the transportation cost (value of time, or differentiation-distaste) parameter exceeds \$1, and if firms must commit to the dollar component of their price prior to setting the cent component, then all brand-producing firms set profit-maximizing prices that end in 99¢.

Keywords: Priced to End in 99; 99¢; the 9 fixation; Product Differentiation; Discrete Location Models.

JEL Classification Numbers: D40, L10.

(Draft = 21why99.tex 2000/06/19 21:02)

*I thank Kaushik Basu, Jonathan Shalev, as well as participants in seminars given at Ben-Gurion University, Lund University, and the Center for Operations Research & Econometrics (CORE) at Université Catholique de Louvain, for most helpful comments.

1. Introduction

It is widely observed that most retailers in the U.S. price products and services to end in 99¢. This pricing structure is sometimes referred to as *the 9 fixation.*

Several explanation for this observation have been proposed in the marketing literature (see for example, Wilkie 1990):

Rounding illusions: Consumers tend to approximate the prices they pay by a lower integer or a lower decimal number rather than a higher price. Thus, depending on the level of rounding numbers, consumers may state or report a price of $999.99 as nine-hundred-ninety-nine, as nine-hundred-ninety, or simply nine-hundred dollars. Whence, people tend to under quote a price according to the leading digits of the price. Stores, then, maximize profit by setting the last digits as large as possible, in which case they simply add the relevant sequence of 9s.

Consumers like to receive change: Therefore, if stores take into their pricing consideration the assumption that consumers' utility is enhanced by receiving change, they will maximize profit by handing out the minimum-possible change, which is 1¢. Hence, all prices end in 99¢.

Attractive digits: People find the combinations of 99, 999, 9999, and so on to be "nice." Thus, consumers are attracted to looking at prices involving many digits of nine. Hence, this "elegant" statement of the price serves as a store-advertising mechanism since after looking at the price itself consumers are more likely to pay attention to other details and features of the store.

Image of a discount retailer: Discount stores tend to utilize black & white ads in order to create an image that the store is engaged in a significant cost cutting. Similarly, a price of 99¢ may indicate that a store is concerned with all levels of cost cutting and that even a 1¢-cost reduction is being transferred to the consumers in the form of a 1¢ price reduction.

The purpose of this paper is to construct a very simple environment with utility-maximizing consumers and strategically-pricing firms where equilibrium prices may vary in their *dollar component* but all end have their *cent component* strategically set to 99¢. Three main features of this environment contribute to this 99¢ pricing result. First, prices are decomposed into a *dollar component* and a *cent component.* Dollars are nonnegative integers, and cents are fractions between zero and 0.99 (yes, just like in the real world!) Secondly, stores must commit to their dollar price before they commit to their cent price. That is, in this environment stores or firms first decide what would be the dollar-price range for their product or service, and only later decide how many cents to add to the previously-decided dollar price. Thirdly, the brands are differentiated by either location with a fixed (consumer-invariant) transportation cost, or a fixed-uniform distaste parameter for consuming the less-preferred brand. The concluding section discusses the robustness of the results with respect to changing the assumptions characterizing this environment.

The economics literature did not address the issue of strategic rationalization of this widely-observed pricing structure. Only recently, Basu (1997) suggested a model that yields prices that end in a nine. In his model, prices are decomposed into dollar- and cent-components but consumers are busy and their brains have limited storage capacity, so they ignore looking at the last digits of a price. But, the consumers are rational in the sense that they have rational expectations of the cent component. In other words, they treat the price *as if* it costs the dollar component plus a cent component which is the expected value conditional on the observed dollar component. Consequently, profit-maximizing stores would recognize this consumer behavior and would make the cent component of the price as large as possible. Hence, prices end in 99¢.

Finally, there is a question whether the 99¢ pricing structure is only an American phenomenon. As it turns out, whereas the 99¢ prices are perhaps more visible in the U.S., more and more stores in other countries adopt this pricing structure. Thus, it remains to check how does 99¢ component of the price translates into different currencies with different purchasing power. Gabor (1988, pp.258–259) reports on prices of nylon stockings in England prior to decimalization of the currency. His striking result is presented on a graph of potential consumers as a function of price and shows that the patterns of no change in potential consumers lie in ranges between prices that are just one penny below the round figure. For example, 2s.11d, 3s.11d., etc., up to 9s.11. In his words, "...this price structure has become imprinted on the customers' minds and has found clear expression in their responses." In the 1990s, the $x.99$ pricing structure became visible in Israel as well.

The paper is organized as follows. Section 2 presents the simple environment. Section 3 defines the strategic interaction of firms. Section 4 solves for the 99¢ equilibrium. Section 5 concludes with a discussion of the robustness of our explanation of the 99¢ equilibrium with respect to the assumptions made in this paper.

2. The Environment

Consider a simple model of a market with two stores called A and B selling differentiated brands. Assume that production costs are zero. Following Shilony (1977) and Fisher and Wilson (1995), assume there are two groups of consumers, type α (called brand A oriented consumers) and type β (called brand B oriented consumers). There are $N_\alpha > 0$ type α consumers and $N_\beta > 0$ type β consumers.

Each consumer buys one unit either from store A or store B. Let p_A and p_B denote the prices of the stores, where $p_i \in \{0.00, 0.01, 0.02, \ldots\}$, $i = A, B$. Also, let $T \in \{0.01, 0.02, 0.03, \ldots\}$ denote the extra distaste cost a consumer bears if he buys his less preferred brand. Altogether, the utilities of consumers of type α and type β are assumed to be

$$U_\alpha \stackrel{\text{def}}{=} \begin{cases} -p_A & \text{buying from } A \\ -p_B - T & \text{buying from } B \end{cases} \quad \text{and } U_\beta \stackrel{\text{def}}{=} \begin{cases} -p_A - T & \text{buying from } A \\ -p_B & \text{buying from } B. \end{cases} \tag{1}$$

One way of interpreting this example is as a discrete version of the Hotelling (1929) location model where the two stores locate on opposite sides of a lake or high terrain and where crossing from one side to the other requires paying a fixed transportation cost of T, such as a toll for crossing a bridge. Under this interpretation, the two stores sell homogeneous products that are differentiated only by location.

Let n_A denote the (endogenously determined) number of consumers buying from store A, and n_B denote the number of consumers buying from store B. Then, (1) implies that

$$n_A = \begin{cases} 0 & \text{if } p_A > p_B + T \\ N_\alpha & \text{if } p_B - T \leq p_A \leq p_B + T \\ N_\alpha + N_\beta & \text{if } p_A < p_B - T \end{cases} \quad \text{and } n_B = \begin{cases} 0 & \text{if } p_B > p_A + T \\ N_\beta & \text{if } p_A - T \leq p_B \leq p_A + T \\ N_\alpha + N_\beta & \text{if } p_B < p_A - T. \end{cases} \tag{2}$$

3. Strategic Interaction

The price charged by store p_i, $i = A, B$, is decomposed into two components, the *dollar component* denoted by $d_i \in \{0, 1, 2, 3, \ldots\}$, and the *cent component* denoted by $c_i \in \{0.00, 0.01, 0.02, \ldots, 0.98, 0.99\}$. Thus, $p_i = d_i + c_i$, for $i = A, B$.

The game is divided into four stages. The first two stages are called the *dollar* stages, where in stage I firm A sets d_A and in stage II firm B sets d_B. The last two stages are termed the *cent* stages, where in stage III firm A sets c_A and in stage IV firm B sets c_B. After stage IV, consumers make purchase according to (2) and firms collect their profit. Intuitively, we can think of stores or firms that must commit to the dollar price because of contracts that they write with retailers or advertising agencies that aim the product for a specific income group (the question whether this type of contracts is optimal is beyond the scope of this paper). Section 5 discusses the robustness of our results with respect to this assumption.

In each stage, all firms observe all the actions taken in the previous stages. Firms' objective is to maximize profit given by $\pi_i \equiv (d_i + c_i)n_i$, where n_i are determined in (2).

We will use the following terminology.

Definition 1

Firm i is said to ***undercut*** *firm j if $d_i + c_i < d_j + c_j - T$.*

Thus, undercutting can be interpreted as a price reduction that compensates brand j oriented consumers if they decide to abandon their preferred (or nearby located) brand and to buy the competing brand. Therefore, undercutting can be interpreted as a subsidy for transportation under the location interpretation of this product-differentiation model.

In what follows, $\lfloor x \rfloor$ denotes the *floor* of x which is the greatest integer lower than or equal to x, $x \in \mathbb{R}_+$. $\lceil x \rceil$ denotes the *ceiling* of x which is the lowest integer greater than or equal to x.

Also, in what follows let $d^e_A, c^e_A, d^e_B, c^e_B$ denote equilibrium actions.

4. The 99¢ Equilibrium

In this section I solve for the subgame perfect equilibrium (SPE) for this four-stage game.

The proof of our main proposition is given in Appendix A. We make the following assumptions.

ASSUMPTION 1

- *The transportation cost parameter exceeds or is equal to one dollar.*
  Formally, $T \geq 1$.
- *The number of brand B oriented consumers is not negligible relative to the number of brand A oriented consumers. Formally,*

$$\frac{N_\alpha}{N_\beta} \leq \frac{\lfloor T \rfloor}{0.99}.$$

The first assumption is essential for existence of a SPE, since otherwise firms would be engaged in undercutting each other by reducing the cent-component of their price. The second assumption is not necessary for existence, but is made here solely for the sake of reducing the number of cases to be analyzed off the equilibrium path. First, note that this assumption is *automatically satisfied* for the case where $N_\alpha = N_\beta$, or for any sufficiently large values of T. If this assumption is reversed, say because N_β is very small, then there might be a case that off the equilibrium path firm A will benefit from undercutting B if such undercutting is feasible in stage III.[1]

[1]Equilibrium in such a case still exists and is unique also with $c^e_A = c^e_B = 0.99$. However, in stage II, (6a) should be replaced with $d_B = d_A + \lceil T \rceil$ (i.e., firm B can slightly increase its dollar component without the fear of being undercut). In turn, (3) has to be slightly modified since firm A can also slightly increase its price.

The following lemma characterizes minimum prices in a SPE.

Lemma 1

In a SPE, $d_i \geq \lfloor T \rfloor$.

Proof. If firm i sets $d_i = \lfloor T \rfloor$ and c_i =0, it cannot be undercut (Definition 1) since the undercutting firm will have to set a negative price. ■

For the main proposition, define the following constant

$$\hat{d}_A \stackrel{\text{def}}{=} \left\lfloor \frac{(N_\alpha + N_\beta)(T + 0.01) + N_\beta \left(\lfloor T \rfloor + 0.99\right)}{N_\alpha} \right\rfloor, \tag{3}$$

and the following function

$$\hat{d}_B(d_A) \stackrel{\text{def}}{=} \left(\frac{N_\alpha + N_\beta}{N_\beta}\right)(d_A - T - 0.01) - 0.99. \tag{4}$$

Proposition 1

Under Assumption 1, the following strategies constitute a unique[2] *SPE in pure strategies.*

Stage I:

$$d_A = \hat{d}_A \tag{5}$$

Stage II:

$$d_B(d_A) = \begin{cases} d_A + \lfloor T \rfloor & \textit{if } d_A \leq \hat{d}_A & (6a) \\ d_A - \lceil T \rceil & \textit{if } d_A > \hat{d}_A,\ T \textit{ noninteger} & (6b) \\ d_A - T - 1 & \textit{if } d_A > \hat{d}_A,\ T \textit{ integer} & (6c) \end{cases} \tag{6}$$

Stage III:

$$c_A(d_A, d_B) = \tag{7}$$

$$\begin{cases} \min\{d_B - d_A - T - 0.01, 0.99\} & \textit{if } d_B > d_A + T & (7a) \\ 0.99 & \textit{if } d_A - T \leq d_B \leq d_A + T & (7b) \\ 0.99 & \textit{if } d_B < d_A - T \textit{ and } d_B > \hat{d}_B(d_A) & (7c) \\ 0 & d_B < \min\left\{d_A - T, \hat{d}_B(d_A)\right\} & (7d) \end{cases}$$

[2]To be precise, it is unique up to two off-equilibrium paths given in (7d) and (8d) where a firm which is being undercut is indifferent among all c_is.

Stage IV:

$$c_B(d_A, d_B, c_A) = \tag{8}$$

$$\begin{cases} 0 & \text{if } d_B > d_A + c_A + T & (8a) \\ \min\{d_A - d_B + c_A + T, 0.99\} & \text{if } d_A + c_A - T \leq d_B \leq d_A + c_A + T & (8b) \\ 0.99 & \text{if } \hat{d}_B(d_A) \leq d_B < d_A + c_A - T & (8c) \\ d_A - d_B + c_A - T - 0.01 & \text{if } d_B < \min\left\{\hat{d}_B(d_A), d_A + c_A - T\right\}. & (8d) \end{cases}$$

Whereas the strategies look quite complicated the following corollary establishes a simple unique equilibrium path.

Corollary 1

The following actions constitute the unique equilibrium path:
$d_A^e = \hat{d}_A$, $d_B^e = \hat{d}_A + \lfloor T \rfloor$, *and* $c_A^e = c_B^e = 0.99$.

5. Discussion

An important feature of this model that supports the 99¢ equilibrium is the discreteness of the three main variables: the dollar component, the cent component, and the unit consumption (which could result from product or service indivisibility). Obviously, this feature characterizes most markets in the real world.

Another feature of the model that supports this equilibrium is the assumption about the sequence of moves. Clearly, there is no justification for this assumption, and the dependency of the 99¢ equilibrium on the assumption that all price decisions must be taken sequentially is the weak point of this paper. For this reason, in the remainder of this paper I would like to elaborate on this issue in order to try to convince the reader why at this point I cannot offer an alternative environment for explaining this commonly-observed pricing structure.

I now discuss whether it is possible to reduce the number of stages and reformulate the model by allowing firms to choose the dollar component simultaneously and then the cent component also simultaneously. Unfortunately, it turns out that this reduction to a two-stage simultaneous-move game cannot be solved for a SPE. The reason for this is that in the first stage firms will be engaged in undercutting or raising prices thereby generating

(Edgeworth-type) price cycles with no Nash equilibrium. Thus, there is no difference between this two-stage game and the one-shot discrete-location problem (see Shilony 1997, Fisher and Wilson 1995, or Shy 1996, pp.158–162) where a Nash equilibrium in pure strategies does not exist.

Another environment which must be tried out is to separate the producing firms and the stores, thereby letting the firms decide about the dollar component and then impose a resale-price-maintenance restriction on the dollar component only, and letting the stores decide about the cent component. Unfortunately, similarly to the static reformulation, a Nash equilibrium in (pure) prices does not exist in this environment since firms will engage in price cycles in the first stage of this game. In view of this, one must conclude that the sequential-moves assumption is essential for obtaining this result.

Appendix A. Proof of Proposition 1

Uniqueness follows by the construction of the equilibrium. To demonstrate that the stated strategies constitute a SPE, I will construct the equilibrium backwards, showing that in each stage the proposed strategies are best response to *every* choice of actions in previous stages taking into account the equilibrium strategies to follow in later stages. In what follows, I refer to the conditions by their subequation number marked near the conditions.

Stage IV: If condition (8a) prevails, then firm B is being undercut by firm A (Definition 1) at any level of c_B and therefore earns zero profit. Hence, any deviation from $c_B = 0$ cannot increase B's profit.

Under (8b), first note that firm B cannot undercut A even when it sets $c_B = 0$. Secondly, in order for firm B to avoid being undercut by firm A, it chooses the highest c_B that solves

$$\max_{c_B \leq 0.99} c_B \ \textbf{s.t.} \ d_B + c_B \leq d_A + c_A + T$$

which can be written as $c_B = \min\{d_A - d_B + c_A + T, 0.99\}$.

Under (8c), firm B has the option of undercutting A by setting a sufficiently low c_B. However, undercutting is not profitable since $d_B \geq \hat{d}_B(d_A)$ (where $\hat{d}_B(d_A)$ is given in (4)) implies that

$$N_\beta(d_B + 0.99) \geq (N_\alpha + N_\beta)(d_A - T - 0.01) \tag{9}$$

implying that setting $c_B = 0.99$ is the profit-maximizing action.

Under (8d), $d_B < \hat{d}_B(d_A)$ implies that the inequality sign of (9) is reversed which makes undercutting the profitable action. Hence, firm B undercuts A by solving

$$\max_{c_B \leq 0.99} c_B \textbf{ s.t. } d_B + c_B \leq d_A + c_A - T - 0.01, \text{ yielding } c_B = d_A - d_B + c_A - T - 0.01.$$

Stage III: Under (7a), $c_A = d_B - d_A - T - 0.01$ so $d_B > d_A + T$ implies that $d_B > d_A + c_A + T$. Hence, by (8a), $c_B = 0$ (i.e., firm B is being undercut). Hence, firm A has the entire market and earns $\pi_A = (N_\alpha + N_\beta)(d_A + c_A) = (N_\alpha + N_\beta)(d_B - T - 0.01)$. I now show a deviation from c_A is unprofitable for firm A. If firm A lowers c_A, it still undercuts B, so this deviation only lowers the profit. If firm A sets $c'_A > d_B - d_A - T - 0.01$, we have that $d_B \leq d_A + c'_A + T$, hence by (8b) firm B responds by setting $c_B = \min\{d_A - d_B + c'_A + T, 0.99\}$, thereby 'escaping' from being undercut. Hence, the number of consumers buying from A drops to $n'_A = N_\alpha$. This deviation is not profitable for firm A since

$$N_\alpha(d_A + c'_A) \leq N_\alpha(d_A + 0.99) \leq (N_\alpha + N_\beta)(d_A + 0) < (N_\alpha + N_\beta)(d_A + c_A)$$

where the second weak inequality sign follows from Assumption 1 and Lemma 1 since

$$\frac{N_\alpha}{N_\beta} \leq \frac{\lfloor T \rfloor}{0.99} \leq \frac{d_A}{0.99}.$$

Under (7b) and (7c), by (8b) and (8c) firm B will not undercut in stage IV since it sets either $c_B = d_A - d_B + c_A + T$ or $c_B = 0.99$. Hence, $\pi_A = N_\alpha(d_A + c_A)$ which is maximized at $c_A = 0.99$.

Under (7d), by (8d) firm B will undercut A in stage IV thereby leaving firm A with zero profit regardless of the level of c_A its sets in stage III. Hence, any deviation is not profitable for firm A.

Stage II: Under (6a), if firm B deviates and sets $d_B > d_A + \lfloor T \rfloor$, then by (7a) firm A undercuts in stage III by setting $c_A \leq d_B - d_A - T - 0.01$. By (8a), $c_B = 0$ altogether yielding $\pi_B = 0$. If, instead, firm B deviates by lowering d_B, the equilibrium outcome does not change, unless it undercuts firm A by setting $d_B = d_A - \lceil T \rceil$ which, in the next paragraph, is shown to be unprofitable when $d_A \leq \hat{d}_A$ (in fact by showing that the opposite deviation is not profitable when $d_A > \hat{d}_A$).

Under (6b), we first need to show that $d_B \leq \hat{d}_B(d_A)$ (so (7d) would apply). To establish this note that

$$d_B = d_A - \lceil T \rceil < \hat{d}_B(d_A) = \left(\frac{N_\alpha + N_\beta}{N_\beta}\right)(d_A - T - 0.01) - 0.99 \tag{10}$$

since

$$d_A > \hat{d}_A > \frac{(N_\alpha + N_\beta)(T + 0.01) + N_\beta(-\lceil T \rceil + 0.99)}{N_\alpha}.$$

Next, by (7d), $c_A = 0$, and by (8d), $c_B = d_A - d_B + c_A - T - 0.01$, hence, firm B gains the entire market. If firm B deviates and raises its price to $d'_B = d_A + \lfloor T \rfloor$ it loses N_α consumers to firm A (while still maintaining N_β customers). This deviation is not profitable for firm B since

$$\pi'_B = N_\beta(d_A + \lceil T \rceil + 0.99) \leq (N_\alpha + N_\beta)(d_A - T - 0.01) = (N_\alpha + N_\beta)(d_B + c_B) = \pi_B \tag{11}$$

where the inequality follows from $d_A > \hat{d}_A$ (condition (6b)).

Under (6c), since $d_B = d_A - T - 1 < d_A - \lceil T \rceil$ condition (10) applies so $d_B \leq \hat{d}_B(d_A)$. Hence, $c_A = 0$ by (7d) and $c_B = 0.99$ by (8d). Since $d_A + 0 - (d_B + 0.99) = T + 1 - 0.99 > T$, $\pi_A = 0$ and $\pi_B = (N_\alpha + N_\beta)(d_B + c_B) = (N_\alpha + N_\beta)(d_A - T - 0.01)$. Now, if firm B deviates and raises its price to $d'_B = d_A + \lfloor T \rfloor = d_A + T$, it loses N_α consumers to firm A. Equation (11) shows that this deviation is not profitable for firm B.

Stage I: If A deviates and sets $d_A < \hat{d}_A$, firm B responds by setting according to (6a). The resulting profit is $N_\alpha(d_A + 0.99)$ which is lower than the equilibrium profit $N_\alpha(\hat{d}_A + 0.99)$.

If firm A deviates and sets $d_A > \hat{d}_A$, by (6b) [or (6c)], firm B undercuts and sets $d_B = d_A - \lceil T \rceil$ [or $d_B = d_A - T - 1$]. By (7d), firm A sets $c_A = 0$ and by (8d) firm B completes the undercutting. This deviation reduces the profit of firm A to zero. ■

References

Basu, K., 1997, “Why Are So Many Goods Priced to End in Nine? And Why This Practice Hurts the Producers,” *Economics Letters,* 54: 41–44.

Dixit, A., and B. Nalebuff, 1991, *Thinking Strategically,* New York: W.W. Norton.

Fisher, E., and C. Wilson, 1995, “Price Competition between Two International Firms Facing Tariffs,” *International Journal of Industrial Organization,* 13: 67–87.

Gabor, A., 1988, *Pricing: Concepts and Methods for Effective Marketing,* Cambridge: Gower Publishing Ltd., 2nd edition.

Hotelling, H., 1929, “Stability in Competition,” *Economic Journal* 39: 41–57.

Shilony, Y., 1977, “Mixed Pricing in Oligopoly,” *Journal of Economic Theory,* 14: 373–388.

Shy, O., 1996, *Industrial Organization: Theory and Applications,* Cambridge, Mass.: The MIT Press.

Wilkie, W., 1990, *Consumer Behavior,* New York: John Wiley & Sons, 2nd edition.