The Economics of Brushing Teeth

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Miscellany

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The ever-growing literature on human capital has long recognized that the scope of the theory extends well beyond the traditional analysis of schooling and on-the-job training. Migration, maintenance of health, crime and punishment, even marriage and suicide, are all decisions which can usefully be considered from the human capital point of view. Yet economists have ignored the analysis of an important class of activities which can and should be brought within the purview of the theory. A prime example of this class is brushing teeth.[1]

The conventional analysis of toothbrushing has centered around two basic models. The "bad taste in one's mouth" model is based on the notion that each person has a "taste for brushing," and the fact that brushing frequencies differ is "explained" by differences in tastes. Since any pattern of human behavior can be rationalized by such implicit theorizing, this model is devoid of empirically testable predictions, and hence uninteresting.

The "mother told me so" theory is based on differences in cultural upbringing. Here it is argued, for example, that thrice-a-day brushers brush three times daily because their mothers forced them to do so as children. Of course, this is hardly a complete explanation. Like most psychological theories, it leaves open the question of why mothers should want their children to brush after every meal. But it does at least have one testable implication: that individuals from higher social classes will brush more frequently.

In these pages I describe a new model which is firmly grounded in economic theory and which generates a large number of empirically testable hypotheses. I then show that the predictions of the model are supported by the data.

EDITOR'S NOTE.—This paper derives from the Princeton oral tradition.

I wish to thank my dentist for filling in some important gaps in the analysis, and my colleague, Michael Rothschild, for insightful kibitzing. Support for this research is graciously solicited.

[1] The analysis to follow can also be applied to such important problems as combing hair, washing hands, and cutting fingernails, as I hope to show in a series of future papers.

The basic assumption is common to all human capital theory: that individuals seek to maximize their incomes. It follows immediately that each individual does whatever amount of toothbrushing will maximize his income. The "mother told me so" model can be considered as a special case where the offspring only does as he or she is told, but the mother's decisions are governed by income maximization for the child. Thus, offspring will behave *as if* they maximized income.

An example will illustrate the usefulness of the model. Consider the toothbrushing decisions of chefs and waiters working in the same establishments. Since chefs generally come from higher socioeconomic strata, the "mother told me so" model predicts that they will brush more frequently than waiters. In fact, it has been shown that the reverse is true (Barnard and Smith 1941). Of course, the human capital model predicts precisely this behavior. On the benefits side, chefs are rarely seen by customers and work on straight salary. Waiters, by contrast, are in constant touch with the public and rely on tips for most of their income. Bad breath and/or yellow teeth could have deleterious effects on their earnings. On the cost side, since wages for chefs are higher, the opportunity cost of brushing is correspondingly higher. Thus, the theory predicts unambiguously that chefs will brush less. It is instructive to compare this rather tight theoretical deduction with Barnard and Smith's glib attribution of the observed differences to the different hygiene standards in the birthplaces of the individuals. (The chefs were born mostly in France, while the waiters were largely Brooklynites.)

I. Review of the Literature

A substantial literature on dental hygienics exists. It is ironic that economists are almost completely unaware of these studies, despite the fact that most economists brush their teeth.

The best empirical study was conducted by a team of researchers at the University of Chicago Medical Center in 1967. They compared toothbrushing habits of a scientifically selected sample of 27 sets of twins who had appeared in Wrigley's chewing gum commercials with a random sample of 54 longshoremen. The twins brushed their teeth an average of 3.17 times per day, while the longshoremen brushed only 0.76 times daily. The difference was significant at the 1 percent level. As noneconomists, the doctors advanced two possible explanations for this finding: either twins had a higher "taste for brushing" than nontwins, or the Wrigley Company deliberately set out to hire people with clean teeth. Further study, they concluded, would be needed to discriminate between these two hypotheses (Baker, Dooley, and Spock 1968). The human capital viewpoint makes the true explanation clear enough. Earnings of models depend strongly on the whiteness of their teeth. On the other hand, no

direct connection has ever been established between the income of longshoremen and the quality of their breath.

Another recent contribution was a survey of professors in a leading Eastern university. It was found that assistant professors brushed 2.14 times daily on average, while associate professors brushed only 1.89 times and full professors only 1.47 times daily. The author, a sociologist, mistakenly attributed this finding to the fact that the higher-ranking professors were older and that hygiene standards in America had advanced steadily over time (Persons 1971). To a human capital theorist, of course, this pattern is exactly what would be expected from the higher wages received in the higher professorial ranks, and from the fact that younger professors, looking for promotions, cannot afford to have bad breath.

II. A Theoretical Model of Toothbrushing

Let w be the wage rate of an individual; let J be an index of his job; and let B be the time spent brushing his teeth. With no loss of generality, I can reorder the jobs so that jobs with higher J are the jobs where clean teeth are more important. The assumed wage function is therefore

$$w = w(J, B), \qquad w_B \geq 0, \qquad w_{BJ} = w_{JB} \geq 0. \tag{1}$$

Since jobs have been reordered, there is no a priori presumption about the sign of w_J. It is also assumed that $w(\cdot)$ is continuous, twice differentiable, and semistrictly quasi-concave in the nonnegative orthant.

Each individual is assumed to maximize his income:

$$Y = w(J, B)(T - B) + P, \tag{2}$$

where T is the fixed amount of time per period available for working or brushing[2] and P is the (exogenously determined) amount of unearned income.[3] That is, each individual selects a value of B to maximize (2). The necessary condition for a maximum is[4]

$$w_B(J, B)(T - B) - w(J, B) = 0. \tag{3}$$

Several important implications follow from (3). First, since both w and w_B are presumptively positive, (3) implies that $T - B$ must be positive. In words, the theory predicts that no person will spend every waking hour brushing his teeth—an empirically testable proposition not derivable from either the "bad taste" or "mother told me" models.

[2] It is assumed, for simplicity, that these are the only possible uses of time. The model can easily be extended to accommodate an arbitrary number of uses of time, as is not shown in an appendix.

[3] A more general model would allow for the possibility that cleaner teeth can lead to a larger inheritance, that is, $P(B)$ with $P'(B) > 0$. For evidence of this, see "Toothpaste Heir Disinherited for Having Bad Breath," *Wall Street Journal*, April 1, 1972, p. 1.

[4] Since w is assumed semistrictly quasi-concave, this is also sufficient for a weak maximum.

Second, (3) can be rewritten

$$\frac{B}{T - B} = \frac{Bw_B}{w}. \tag{4}$$

In words, the ratio of brushing to nonbrushing time is equated to the partial elasticity of the wage with respect to brushing time. So individuals in jobs where wages are highly sensitive to brushing will devote more time to brushing than will others—as indicated in the verbal discussion. Also, for any two jobs with equal w_B's but unequal w's, (3) implies that the higher-wage person will brush less due to his greater opportunity cost.

Finally, consider the important case where (1) is linear in B (though possibly nonlinear in J):

$$w = \alpha(J) + \beta(J)B, \qquad \alpha \geq 0, \qquad \beta \geq 0. \tag{1'}$$

Substituting into (3) and solving yields

$$B = \frac{T}{2} - \frac{\alpha}{2\beta}. \tag{5}$$

In jobs where brushing is immaterial to success, $\beta \to 0$, so (5) calls for a corner maximum with $B = 0$. Thus, we have a second strong prediction from the model: such persons will never brush. At the other extreme, as the ratio α/β approaches zero, (5) implies $B \to T/2$. In words, individuals whose wages depend almost exclusively on the whiteness of their teeth (M.C.'s of television quiz shows are a good example) will spend approximately half their lives brushing. Again, no sociological theory can generate predictions as strong as this.

III. A Regression Model

The implications of the model can be put to an empirical test thanks to a recent cross-section study of American adults in the civilian labor force conducted by the Federal Brushing Institute. In its Survey of Brushing, the institute collected data on toothbrushing frequency and many socioeconomic characteristics of 17,684 adults in 1972. From these data, the following regression model was formulated:

$$\begin{aligned} NBRUSH = {} & a_0 + a_1 AGE + a_2 WAGE + a_3 NTEETH + a_4 S \\ & + a_5 EXP + a_6 FDUM + a_7 Y + u. \end{aligned} \tag{6}$$

The dependent variable is the number of times teeth were brushed during the year. *AGE* is included as a proxy for the number of years remaining before the individual's teeth fall out. Viewing brushing as a human investment clearly implies that $a_1 < 0$. *WAGE*, of course, measures the opportunity cost of time; so $a_2 < 0$. *NTEETH* is the number of teeth in

the person's mouth. Since brushing time is nearly independent of the number of teeth brushed, having more teeth should certainly encourage more brushing. S and EXP are, respectively, years of schooling and work experience. They are included because this is a human capital model; although there are no a priori expectations about the signs of a_4 and a_5, both should have high t-ratios. $FDUM$ is a dummy for persons who live in an area with fluoridated water supply, included since there is some substitution in the production function for good teeth between brushing and fluoridating the water. Finally, Y is nonlabor income, which enables us to estimate the income effect on toothbrushing frequency.

Since I have argued above that $WAGE$ should depend on $NBRUSH$, equation (6) was estimated by the instrumental-variables technique. Denture wearers were included in the sample, but 189 people with no teeth at all were omitted from the analysis. The empirical results are reported below, with standard errors in parentheses:

$$\begin{aligned} NBRUSH = {} & \underset{(0.63)}{2.04} - \underset{(0.001)}{0.006}\, AGE - \underset{(0.001)}{0.096}\, WAGE + \underset{(0.009)}{0.054}\, NTEETH \\ & + \underset{(0.0002)}{0.0043}\, S - \underset{(0.0001)}{0.0022}\, EXP - \underset{(0.027)}{0.146}\, FDUM \\ & + \underset{(0.0002)}{0.0006}\, Y, \qquad R^2 = .79, \qquad SE = 0.056. \end{aligned}$$

By any standards the results are very good. The R^2 is very high for cross-section work, indicating that the data have been successfully mined. All the variables suggested by the theoretical model are highly significant and, wherever the theory implied a priori sign restrictions, they are satisfied.

In summary, the survey data strikingly confirm the predictions of the theoretical model of toothbrushing presented here. Of course, this is only one of many possible tests of the theory. But it does point out the usefulness of human capital concepts in understanding dental hygiene. Hopefully, these results will stimulate renewed interest in such questions on the part of economists.

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