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# Formulation of the Demand for Cigarettes Incorporating Information as Second Capital: A Revision and An Extension

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## 1. Introduction

The purpose of this paper is to deduce an equation for the demand for cigarettes by explicitly incorporating the information disseminating health hazards of smoking within the analytical framework of utility maximization. That is, the paper provides a deductive argument to derive a testable hypothesis that the information dissemination reduces the demand for cigarettes, besides clarifying the other properties of the cigarette demand function.

The initial motivation behind this paper lies in this author's discovery, when Yimin Zhou, the co-author of our earlier paper, and this author decided to write a paper on the impact of information and knowledge on cigarette consumption, that most of the authors merely posit their statement of hypothesis in the form of a testable equation without deducing it within some analytical framework of optimization; and, further, that information was not incorporated as a variable, though some authors examined the impacts on the demand for cigarettes of their positive and negative advertising and the 1964 U. S. Surgeon General's Report in their empirical studies. It was the purpose of this author to formally incorporate and deduce information as part of the statement of hypothesis expressed in the form of the cigarette demand equation derived within a utility maximization model, instead of merely positing such statement of hypothesis (i.e., the equation). This objective has led the author to study the subject of information in some depth.

George J. Stigler launched information as a subject of economic analysis almost forty years ago.<sup>1)</sup> His study took place within the framework of the "economics of search" in today's jargon. Since then, the economics of information has expanded into several

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1) R.H. Coase, in *Essays on Economics and Economists* (Chicago: University of Chicago Press, 1994), 204, cites, as George J. Stigler's major contribution to economic theory prompting the Swedish Academy to special commendation, his "The Economics of Information," originally published in *Journal of Political Economy*, Vol. LXIX, No. 3 (June, 1961): 213-225, and later reprinted in his book, *The Organization of Industry* (Homewood, Ill.: R. D. Irwin, 1968), 171-190. It is worth noting that Stigler in section 3 of his article examines advertising from the perspective of buyers as an instrument to learn of sellers' identities (e.g., price, quality, location, etc.).

directions: contracts, moral hazard, adverse selection, insurance policy design, design of an incentive mechanism, principal-agent relations, advertising, signaling, and the impact of information on Pareto efficiency of a competitive market.<sup>2)</sup> All these areas of the study of information stem from the fact that the costs of acquisition and dissemination of information are significant and vary among individuals and other economic agents.

Information is clearly recognized as a vital resource. It is so vital that information has been referred to as “second capital.”<sup>3)</sup> It will be unambiguously clear that the perception of information (and knowledge) as “second capital” occupies the central place of the current paper.

The purpose of this paper is to present a revised and extended version of part of the paper, originally co-authored with Yimin Zhou, “Demand for Cigarettes in Japan: Impact of Knowledge and Information on Cigarette Consumption in Light of Japanese Prefectural Data,” To be specific, this paper treats information and knowledge regarding health hazards of smoking as personal capital (or consumption capital) in the “household production function” (or the personal production function), *a la* Becker and Stigler.<sup>4)</sup>

In another vein, the approach, *a la* Becker and Stigler, adhered to in this paper, allows the author to deduce the differences in cigarette consumption per capita among the prefectures to differences in price, income per capita and the level of information dissemination, hence, sealing out any differences in tastes and preferences as a basis for differences in per capita cigarette consumption among prefectures. That is, the identical preference function is

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2) A few samples of the literature on these topics are given as follows: Gerald A. Feltham, Amin H. Amershi and William T. Ziemba (eds.), *Economic Analysis of Information and Contracts: Essays in Honor of John E. Butterworth* (Boston: Kluwer Academic Publishers, 1988); Brian Hillier, *The Economics of Asymmetric Information* (New York: St. Martin's Press, 1997); M. Pauly, “The Economics of Moral Hazard: Comment,” *American Economic Review* (June 1968), 531-537; Philips, Lous, *The Economics of Imperfect Information* (Cambridge; New York: Cambridge University Press, 1988); Theodore Groves, Roy Radner and Stanley Reiter (eds.), *Information, Incentives and Economic Mechanism: Essays in Honor of Leonid Hurwicz* (Minneapolis: University of Minnesota Press, 1987); G.C. Archibald, *Information, Incentives and the Economics of Control* (Cambridge; New York: Cambridge University Press, 1992); Hiroaki Ishigaki, *Essays on Advertising in Industrial Organization* (Ph.D. Dissertation, Department of Economics, Purdue University, 1998); Michael Spence, “Job Market Signaling,” *Quarterly Journal of Economics* (August 1973), 355-374; and J. Stiglitz, “Information and Economic Analysis: A Perspective,” *Economic Journal Supplement to Volume 95* (1985), 21-41; S. Shavell, “On Moral Hazard and Insurance,” *Quarterly Journal of Economics* (November 1979), 541-562; and G. A. Akerlof, “The Market for Lemons: Quality Uncertainty and the Market Mechanism,” *Quarterly Journal of Economics* (August 1970), 488-500.

3) I have encountered the expression “second capital” some years ago but I am unable to identify either the writer's name or the work for citation. This expression conveys well the role of information and knowledge in the current paper.

4) Gary Becker and George Stigler, “De Gustibus Non Est Disputandum,” *American Economic Review*, 67, no.2 (1977): 76-90 and Gary S. Becker, “Preferences and Values,” 1-23 in Gary S. Becker, *Accounting for Tastes* (Cambridge, Massachusetts: Harvard University Press, 1998).

assumed for a representative consumer both within a prefecture as well as across the prefectures. It will be deduced that this personal capital affects the calculus of the “cost of smoking originating from within.” To be exact, it will be shown in the next section that the greater is the level of information and knowledge, the higher (not lower) is the “cost of smoking originating from within,” hence reducing the consumption of cigarettes, which, in turn, attenuate both personal and social costs of smoking in the form of medical expenses and lost incomes due to smoking-related sicknesses and deaths.

This paper introduces information initially as a parameter; then, invoking the implicit function theorem, it derives the cigarette demand function as a function of income, prices and information; and, further, by using the envelope theorem, it will deduce the statement of hypothesis in the form of equation in which it will be concluded that the greater the level of dissemination of information and hence of knowledge regarding health hazards of smoking, the lower the level of per capita consumption of cigarettes, in addition to the familiar negative relationship between the price of cigarettes and their consumption per capita on the one hand, and the positive relationship between per capita income and per capita consumption of cigarettes on the other.

For the detailed literature review on the study of the demand for cigarettes around the world, references, stylized facts on the Japanese consumption of cigarettes, the industrial organization of cigarette production and distribution in Japan, and the empirical study of the Japanese demand for cigarettes by using prefectural data, see Yorozu and Zhou (1999) which is the only study of this type available on Japanese smoking.

## 2. Formulation of the Model

The author pursues his inquiry in the following framework of constrained maximizing behavior.

The consumer maximizes

$$u = u(s, x) \text{ subject to } s=h(c; I) \text{ and } pc + qx = M, \quad (1)$$

with the following notation:

$u$  = utility function

$s$  = smoking appreciation

$c$  = cigarettes

$x$  = composite market good

$h$  = household production function for smoking

$I$  = the level of dissemination of information about health hazards of smoking

(parameter)

$p$  = price of cigarettes (parameter)

$q$  = price of composite good (parameter)

$M$  = money income (parameter).

The function  $u$  is a utility function which applies commonly to a representative consumers across all the prefectures; it is a function of “smoking appreciation” (not a function of cigarettes per se) and the composite market good embracing all other market goods; the function  $u$  is postulated to be increasing and concave in  $s$  and  $x$  and twice continuously differentiable; the function  $h$  is a “personal production function” through which the consumer “produces” “smoking appreciation” with cigarettes and the information on health hazards of smoking; the function  $h$  is also postulated to be increasing and concave in  $c$  and twice continuously differentiable.

Two remarks are in order: (i) the notion of a representative consumer is invoked; i.e., all consumers within a prefecture as well as across the prefectures have the same preferences and, hence, this assumption will avert the exposition from slipping into a stalemate of concluding that people in one prefecture have a different cigarette consumption pattern from those in another prefecture because people in one prefecture have a different preference from those in another; the author must construct the model so that its conclusion will not hinge upon “differences in tastes; as well articulated in Stigler and Becker (1977). Thus, the differences in the consumption of cigarettes between prefectures will be accounted for in terms of differences in income, price, and information dissemination.

(ii) Though parameter  $I$  is not expressed in terms of accumulation as in Stigler and Becker,  $I$  may be referred to as a component of “consumption capital,” “personal capital,” or “human capital.” These phrases express the earlier references to information as “second capital.”

By substitution, the optimization model in (1) can be rewritten as

$$\underset{c,x}{\text{Maximize}} w(c, x; I) \text{ subject to } pc + qx = M. \quad (2)$$

The corresponding Lagrangian function is

$$L(c, x, \lambda) = w(c, x; I) + \lambda (M - pc - qx). \quad (3)$$

Ensuring the sufficient second-order condition to hold; i.e., the bordered Hessian determinant of the second partials of the Lagrangian being positive) and invoking the Implicit Function Theorem, from the set of the first-order conditions, we derive a set of choice functions (demand functions for cigarettes and composite market good and the function for marginal utility of money) as given below

$$\begin{aligned}
c &= c^*(p, q, I, M) \\
x &= x^*(p, q, I, M) \\
\lambda &= \lambda^*(p, q, I, M).
\end{aligned}
\tag{4}$$

By substituting these functions into the objective function in (2), we define the following maximum value function

$$w^*(p, q, I, M) \equiv w(c^*(p, q, I, M), x^*(p, q, I, M); I) \tag{5}$$

where  $w^*(p, q, I, M)$  is most frequently referred to as the indirect utility function.

Our task at hand is to deduce the characterization of the cigarette demand function. We deduce  $\partial c / \partial p < 0$  by deriving the Slutsky equation via the duality theory and the envelope theorem, and further by assuming that cigarettes are a normal good (i.e.,  $\partial c / \partial M > 0$ ), or more mildly assuming that at least cigarettes are not a Giffen good.

To deduce the impact of information dissemination of health hazards of smoking on the consumption of cigarettes is slightly more complicated. The deduction process hinges on the following observation on the maximizing behavior depicted in (2). We observe that parameter  $I$  enters only the objective function and that it does not enter the constraint. Therefore, so long as the values of  $c$  and  $x$  are chosen and held so as to satisfy the constraint, the constraint has no binding effect on the choice of the maximizing value of parameter  $I$ .

This observation simplifies the primal-dual analysis of the maximization problem to the following expression

$$\underset{I}{\text{Maximize}} F(c, x, I) \equiv w(c, x, I) - w^*(I). \tag{6}$$

The first-order condition gives the celebrated envelope result for the unconstrained maximization:

$$w_I = w_I^*. \tag{7}$$

In view of (5) and (7), we have

$$w_I^*(I) \equiv w_I(C^*(I), x^*(I), I). \tag{8}$$

Note that  $c^*(I)$  and  $x^*(I)$  are the suppressed versions of (4) with the understanding that parameter  $I$  does not enter the constraint and that the values of  $c$  and  $x$  are chosen and held

so as to satisfy the constraint.

Because, by construction, the primal-dual objective function (6) has a maximum value of zero, the sufficient second-order condition is:

$$F_{II} < 0 ; \quad \text{that is, } w_{II} - w_{II}^* < 0. \quad (9)$$

Differentiating both sides of (8) with respect to  $I$ , we obtain

$$w_{II}^* \equiv w_{Ic}(\partial_c^* / \partial I) + w_{Ix}(\partial_x^* / \partial I) + w_{II}. \quad (10)$$

Imposing the sufficient second-order condition upon (10) and using Young's theorem yield:

$$w_{II}^* - q_{II} \equiv w_{cI}(\partial_c^* / \partial I) + w_{xI}(\partial_x^* / \partial I) > 0. \quad (11)$$

The qualitative analysis of the impact of information dissemination on cigarette consumption is embodied in (11). However, the relation (11) does not lead to any specific refutable statement of hypothesis. That is, the assumptions that have been made heretofore are not sufficiently specific for this author to derive a specific property of the cigarette demand function in terms of the relation between  $c^*$  (the quantity of cigarettes demanded) and  $I$  (the level of dissemination of information on health hazards of smoking). Below will be made specific assumptions which are plausible enough to not invite any serious damage to the deductive process.

Assuming safely that  $w_{xI}$  is zero (i.e., the dissemination of information on smoking-hazards does not affect the marginal utility of consuming non-cigarette goods), we can derive the second characterization of the demand for cigarettes as expressed in (12).

$$w_{cI}(\partial_c^* / \partial I) > 0. \quad (12)$$

Assuming again safely that  $w_{cI} < 0$  (i.e., the dissemination of information on smoking hazards reduces the marginal utility of cigarette consumption), the author is able to deduce the following statement of hypothesis:

$$\partial_c^* / \partial I < 0. \quad (13)$$

Thus, it is now deduced that an increase in the level of dissemination of information on health hazards of smoking will reduce cigarette consumption. Therefore, we conclude that, at least theoretically, the dissemination of information on health hazards of smoking is an effective public health policy.

### 3. Concluding Remarks

This deductive study of the demand for cigarettes was prompted by its peculiar backdrop: the extreme paucity of such studies in Japan, Japan topping the other industrialized countries in per capita consumption of tobacco, the tobacco industry having been a Japanese government monopoly, the absence of anti-smoking ordinances and regulations, the government's distinctively dead-silent policy on disseminating the information regarding health hazards of smoking, all of which are specific to Japan, and the puzzling peculiarity among the prevailing studies on cigarette demand of positing the cigarette demand equation in an *ad hoc* manner and the absence of a systematic incorporation of information in deducing the cigarette demand function.

The central theme of this paper originates in this author's perception of the low level of public awareness regarding health hazards of smoking which is attested to by the Japanese smoking behavior. Clearly, as many previous studies have indicated, one dominant form of public policy to abate smoking (and hence both private and social costs of smoking through smoking-related diseases and deaths) is to raise the price of cigarettes, which is to raise "the cost of smoking from without."

This paper embraces two deductive arguments rendering support to the testable statement of hypothesis that the effective use of dissemination of the information regarding smoking-related health hazards is a potent public policy. One argument is that the dissemination of information raises the "cost of smoking from within," and hence reduces cigarette consumption. The other argument is a corollary to the first argument: the dissemination of information is pivotal to the enactment of anti-smoking ordinances and legislation, through elevating public awareness of smoking-related health hazards (because it raises the "cost of smoking from within,") and therefore inducing the public and their leadership to place anti-smoking issues and the need for anti-smoking ordinances on the Japanese political and social agenda, both locally and nationwide. Without the elevation of public awareness of smoking-related health hazards, the public will neither perceive a need for such ordinances and legislation nor support them.

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