A Behavioral Model of Addiction

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Abstract

This study presents a behavioral model of addiction in which cognitive dissonance theory and multi-self theory are combined. It is shown that smokers under information filtering show more inelastic responses to the changes in price and income compared with smokers without information filtering. Several other implications which are consistent with empirical observations will be derived for addictive behavior.

Introduction

This study introduces a behavioral model of addiction — smoking in following example. Behavioral model introduced here combines "cognitive dissonance theory" (Gilad-Kaish-Loeb who will be denoted by GKL hereafter, 1985, 1987) with "two self theory" (Thaler-Shefrin 1981). We will show that the behavioral model of addiction introduced below yields many important insights about addictive behaviors and the demand for addictive goods, some of which have been

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inexplicable by rational addiction models (see, notably, Becker and Murphy,1988).

GKL (1987) incorporate surprise theory developed by Cohen and Axelrod (1984) with cognitive dissonance theory which is introduced in economics by Akerlof and Dickens (1982). Surprise in Cohen and Axerlod is defined by the discrepancy between the utility one expected and the actually realized utility. Cognitive dissonance theory states that, even if there exists surprise, and thus, even if the objective function is found to be false, the updating of the objective function will not take place as long as surprise is below a certain threshold level. When surprise due to a misspecification of the objective function is not large enough, information filter is activated and this filter blocks out dissonant information from influencing the parameters in the decision model [1].

It seems to me that GKL implicitly assume the existence of other self in decision making process [2]. In their model, it is not clear *who* controls the information filter. This study combines two self theory with cognitive dissonance theory. We assume there are planner and doer inside an economic man. Following Thaler and Shefrin, we will assume planner provides for doer the objective function to be optimized. In the simple model introduced in below, it is planner who controls information filter.

Section Ⅱ introduces the basic model we will use in this study. Section Ⅲ

[1] In Kang (1993), I analyze the smoking behavior using the household production theory. I would prefer the model presented in this study as the present model is more easily applicable to several economic behaviors.

[2] We can make k an endogenous variable, for example, as a function of c or z (as for notations, see below).

derives the demand function for cigarettes and indicates the main implication that smokers under information filtering show more inelastic responses to the changes in price and income level. Concluding remarks are given in final section.

Basic Model

At first, we will describe the behavior of a smoker at his or her Becoming Stage (the first experience of smoking, see Leventhal and Cleary, 1980, who define the developmental history of individual smoker in four stages. These are Preparation, Initiation, Becoming and Maintenance Stages). For simplicity, we will introduce time specific model here, and firstly describe the choice at time $t=0$. We assume smoking behavior is accompanied by both positive and negative utilities. Negative utilities are, of course, resulted from the harmful effects of smoking on health. Denoting the true utility function of smoking by $W(c)$, where c means the consumption level of cigarette, we define (subscript indicating time t for relevant variables will be omitted in below for $t=0$),

$$W(c)=u(c)-v(c) \tag{1}$$

Where u is positive mental utility obtained by smoking ($u'>0$, $u''<0$) and v is the measure of disutility of harmful effects of smoking on health. In (1), v is defined as $v'>0$ for all $c>0$, i.e., v is defined in a way that larger v means larger disutility measured in absolute term. We assume $v'>0$, $v''<0$. $v''>0$ implies that the marginal harmful effects of smoking are decreasing as consumption of cigarettes increases. This assumption implies that additional cigarettes for heavy smokers are less harmful than starting 2 or 3 cigarettes of adolescents. For

example, medical reports by Nakanishi-Fujiwara (1989) and Yanagida (1989) support this assumption. According to these studies, nicotine dependence can be found at the very low level of cigarette consumption.

For simplicity, we assume the consumption of cigarette is separable from consumptions of all other goods (see Morishima, 1973, for extensive review about separability of utility). We can extend the basic model to more than 2 goods case without altering the main implications of the model. The overall true utility function for this smoker (denoted by Wtr, tr for true) is defined by

$$W_{tr}(c, x) = W(c) + W_r(x) \tag{2}$$

Where x means all other goods and Wr is the utility function of x. Budget constraint given to this smoker is,

$$pc + x = M \tag{3}$$

P is the relative price of cigarette and M is income level. We assume smokers at Becoming Stage do not know the existence of harmful effects of cigarette, v(c), and behave as if their objective function is (4) below. See Leventhal and Cleary and references therein for supporting evidences for this assumption. The main results of this study remain valid as long as personal information about v is not perfect,

$$W_{fa}(c, x) = u(c) + W_r(x) \tag{4}$$

In (4), fa means false. We will adopt the two self theory in this model and assume that there are two self, planner and doer, inside an economic man or a smoker under our analysis. The first misspecification of the objective function is made by planner, who provides (4) for doer. This misspecification of the objective function yields surprise to planner which is defined by the discrepancy between the expected outcomes and realized outcomes. In the above framework, surprise (denoted by S) is defined by,

$$S = W_{fa} - W_{tr} \qquad (5)$$
$$= v(c)$$

This surprise does not necessarily trigger the revision or updating of the false objective function. Following GKL, we assume there exists “disutility of revising the objective function (i.e., psychological cost of admitting that one made a mistake)”, which is fixed at a certain level denoted by k. If surprise is large enough or if the level of k is small enough, the updating of the objective function will be made. Otherwise, information filter is activated and the revision of the false objective function is not to be made. In this model, planner controls the switch of the information filter. More specifically, we assume planner’s behavior can be described as follows,

Planner’s choice

If $S > k$, then revise the objective function

Otherwise, activate information filter and maintain the false objective function

In Thaler-Shefrin model wherein the concept of two self (or multi self) is firstly

introduced in economics, planner is supposed to concern about long run objective function while doer is interested only in short run results. In our model, planner's behavior is also described as myopic [3].

Thus, when $S < k$, planner provides the false objective function (4) for doer disregarding the newly obtained information from experiences of smoking. We will call smokers of this type as "filtering-on smokers", and so, filtering-off smokers will mean smokers with $S > k$, who behave under true utility function. Psychologists McKennel and Thomas (1967) named this filtering-on smokers as dissonant smokers, which was a misnomer as Eiser et. al (1995) correctly indicated. From (5), it follows directly that S is an increasing function in c, which means that heavy smokers or veteran smokers are more willing to quit smoking. Hiraga (2004) reports that rate of cessation and abstinence is about 20% higher for heavy and veteran smokers compared with younger smokers. The above framework is also consistent with the well known fact that smokers often reveal selective exposure to information related with the harmful effects of smoking. Further, this model can support the general view that preventing initial attempts and facilitating negative interpretations of initial attempts are the most important and effective anti-smoking policy tools (see March, 1978, Schwenk, 1984).

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[3] We can define planner in the same way as in Thaler-Shefrin. It would be inadequate to assume, however, that smokers at the Becoming Stage have perfect information about long-run consequences of smoking. It would be more interesting if we define planner as the one who optimizes the long-run objective function under uncertainty.

Demands for Cigarettes

The harmful effects of smoking on health are cumulative so that at time t ($t>0$, Maintenance Stage), v(c) will be redefined as

$$v(c_t)=v(c_t, z_t) \qquad (6)$$

Where $Z_t=\sum_{i=0}^{t-1} C_i$ and $\partial v/\partial Z_t>0$

Along with the observation that surprise S is an increasing function of time t, it follows that veteran smokers are more willing to revise the utility from smoking as indicated above. After revision of the objective function, they will quit smoking if $u(C_t)-v(C_t, Z_t)$ is negative or sufficiently small. Interested readers would notice that, in this framework, the true marginal utility of smoking could be negative if smokers are filtering-on.

From the above model, we can calculate the responses of smokers to the changes in several parameters. Here, we will examine the difference in demand functions between filtering-on smokers and filtering-off smokers. We will examine the effects of price changes at time t (subscript t will be omitted in below. Equations introduced for time 0 remain valid for $t>0$ as we assume past consumption affects only on v). From (2) and (3), filtering-off smokers' responses to price changes can be calculated as follows,

$$(\partial c/\partial p)^*=(-\lambda/D^*)-c(\partial c/\partial M)^*$$

Where λ is Lagrangean multiplier and D^* is the relevant determinant, $D^*=-p^2$

$W_r'' - (u'' - v'') > 0$, and

$$(\partial c/\partial p)^* = (-pW_r''/D^*)$$

Next, as for filtering on smokers, the corresponding responses can be calculated from (3) and (4) as follows,

$$\partial c/\partial p = -(\lambda/D) - c(\partial c/\partial M)$$

Where D is the relevant determinant, $D = -p^2W_r'' - u'' > 0$, and

$$\partial c/\partial M = (-pW_r''/D)$$

As $D > D^*$, it follows, comparing at the same level of consumption c and x

$$(\partial c/\partial M)^* > (\partial c/\partial M), \ |(\partial c/\partial p)^*| > |\partial c/\partial p|$$

We assume u'－v' is positive for relevant level of c (otherwise, one will not smoke after all) and $-pW_r'' - u'' > v''$ so that $D^* > 0$. Thus, compared at the same level of cigarette consumtion, filtering on smokers who behave under the false objective function reveal more inelastic responses to price and income changes. Both income and substitution effects become smaller if the smoker behaves under information filtering. These comparisons are, of course, made with an assumption that utility functions are same for all smokers. Or, one would rather prefer an interpretation that the same smoker shows more inelastic responses when he behaves under information filtering. Intuitively, we can explain this

result like this. As for filtering on smokers, implicit or real price of cigarettes measured in utility terms is $\lambda p + v'$ where is λ the utility measure of price. So, for example, 5% changes in cigarette price means less than 5% change in implicit or real price for filtering on smokers[4].

It may be true that the control of planner over doer is not always perfect and conflicts between planner and doer would occur from time to time. Self control is not always perfect and one would agree that this is a basic theme of Freudian psychology (see also, Winston (1980) who described an agent whose self control is not perfect). This conflict, in my view, can explain the observed facts why some smokers do not want smoke but smoke, why many smokers want to quit smoking but fail, and why some smokers who have failed in cessation in past do not challenge again but keep smoking. In rational addiction theory, smokers who want to quit but fails are said to be in search process under uncertainty for right method of cessation. However, many smokers who have failed in cessation in past simply give up the challenge without searching more adequate methods (see Hiraga for examples). Our model presented above is a bounded rational addiction theory, bounded in a sense that there exists positive cost of updating the objective function.

Concluding Remarks : rational irrationality?

Economics (notably, economists of Chicago school) often defines rationality by

[4] In a sense, inelasticity of whatever kind would be a result of a sort of irrational behavior. In my knowledge, this is the first result which suggests a possible relation between rationality and elasticity.

the optimization behaviors which are resulted in marginal conditions and a sort of efficiency. This study shows that the optimization of false objective function in a certain case is also resulted in marginal condition and satisfies a sort of efficiency conditions. Then, are smokers described in this study rational? Simply and apparently, the answer will depend on the definition of human rationality. As long as we define the rationality by optimizing behavior, smokers described in this study are rational. This would suggest that human rationality in economics requires more conditions in addition to optimizing behavior.

Smokers in this study maximize the false utility function knowing that it is a false one. Their behavior is logical as long as there exists the revision cost of k which is large enough. One could interpret this revision cost of k as a sort of transaction cost with which economists are more familiar. Further, interested readers would note that every problem arises because smokers at the Becoming Stage are assumed to have a false objective function. And, thus, the model we introduce in this study could be viewed as a specific choice model with transaction costs and uncertainty at the first stage of choice.

Finally, I want to introduce some recent literature closely related with the present study. Benabou and Tirole (2004) studied the “willpower based choice model” and introduces a specific model of self-control. Filtering-on agents in this study would correspond no-willpower option case or “give-up case in willpower activity” in Benabou-Tirole model. Bernheim and Rangel (2004) presented a neuroscience model wherein addicts understand their objective function is false, but still maintain the false objective function. The bounded rationality model we introduced in this study can easily be applied to several other problems. In a

footnote, I will introduce an example of application of this basic model to show the wide applicability of the basic model in this study.[5]

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[5] Here, we will show an example of application of the basic model introduced in this study. The case of over-investment to education can be analyzed within the above framework. Persistent problem of educated unemployed has been a puzzle for economists. For example, in India, the number of unemployed among the educated increased from 0.16 million in 1953 to 16.45 million by 1986 with an annual growth rate of 22.2% (Blaug et. Al., 1969, see also Upadhyay, 1994). As for the USA, Sicherman (1991) indicated about 40% of workers are overeducated. Cognitive dissonance model within two self framework can explain this persistent overinvestment to education as follows :
Define the utility of parents as $U=U(C, Q)$ where C is parents' own consumption level and Q represents quality of children. We assume the number of children is given. The child quality Q is produced by the education function which will be defined as $Q=f(E, x^*)$ where E means the level of education and x^* is true parameter representing children's unobservable ability. We assume some parents overestimate their children ability so that $x'>x^*$ (see Fields, 1974) where x' means parents subjective estimate of children ability. Further, define E^* as a level of education corresponding to the correct estimate x^* and E' as a level of education corresponding to the false estimate x'. It is easy to show that, $E'>E^*$, $C^*>C'$ and $U(C^*E^*)>U(C'E')$. Parents surprise in this case is defined as the difference between $U^*=U(C^*E^*)$ and $U'=U(C'E')$, and if k is larger than S, the surprise, parents overinvestment to their children's education will persist.

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