Sinful Indulgences, Soft Substitutes, and Self-Control

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Abstract

For several harmful goods (e.g., junk food and cigarettes), less-harmful subsitutes are available (e.g., light cigarettes and reduced-fat junk food). We develop a simple individual-decision model to analyze the effects of less-harmful subsitutes on consumption and health outcomes.

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1. Introduction

A "harmful good" is a product that is desired but has negative side-effects (e.g., junk food or cigarettes). For several harmful goods, less-harmful substitutes are available (e.g., reduced fat junk food or light cigarettes). In this paper, we analyze the effects of less-harmful substitutes on consumption and health through a simple, rational individual-decision model.

A less-harmful substitute can directly reduce the probability that consuming the good leads to a bad outcome (e.g., heart disease or lung cancer) for a given level of consumption, but it can also encourage more consumption, which may indirectly increase the probability of a bad outcome given that the less-harmful substitute is still harmful. If the direct effect dominates, then the substitute reduces the probability of a bad outcome. But if the indirect effect dominates, then it increases the probability of a bad outcome.

The model predicts that all people consume more of the harmful good if they consume it in the form of its less-harmful substitute. Moreover, consuming the less-harmful substitute reduces the risks of a bad outcome for people with a sufficiently high taste for the harmful good, but increases the risks of a bad outcome for people with a sufficiently low taste for the harmful good. Finally, if people are able to exercise self-control, then only people with a sufficiently high taste for the harmful good will actually use the less-harmful substitute.

Starting with Becker and Murphy (1988), a large literature analyzes rational addiction and self-control in the consumption of harmful goods. See, for example, O'Donoghue and Rabin (2001, 1999), Gul and Pesendorfer (2004a, b, c), and Benabou and Tirole (2004). Becker et al. (1994) and Gruber and Mullainathan (2002) test implications of the rational addiction model using cigarette consumption data. Smith (2002, 2005) analyzes self-control problems in food consumption from rational and evolutionary perpectives. We appear to be the first to focus on the role of less-harmful substitutes in rational consumption decisions.

2. Theory

Nature starts by choosing individual i's taste for the harmful good, denoted by b_i, according to the uniform distribution on the $[0, 1]$ interval. Individual i chooses how much of the harmful good to consume, $s_i \in [0, \infty)$. Nature then chooses whether the individual has a bad outcome, choosing a bad outcome with probability $p(s_i)$, where $p'(s_i) > 0$, if the individual consumes the harmful good, and with probability $q(s_i)$, where $q'(s_i) > 0$, if the individual consumes the less-harmful substitute. The assumption is that $p'(s_i) > q'(s_i)$ for all s_i, that is, increasing consumption of the harmful good from a given level increases the probability of a bad outcome by a greater extent than does increasing consumption of the less-harmful substitute from that same level. Let d be the cost of a bad outcome for any individual. If Nature chooses a bad outcome, then the individual's payoff is $b_i s_i - d$. If Nature chooses a good outcome, then the individual's payoff is simply $b_i s_i$. The decision problem for an individual who does not consume the softer substitute is:

$$\max_{s_i} b_i s_i - p(s_i)d. \tag{1}$$

The first order condition dictates that the individual consume up until the point s_i^* where the marginal benefit equals the marginal cost:

$$p'(s_i^*) = \frac{b_i}{d}. \tag{2}$$

The decision problem for an individual who consumes the softer substitute is:

$$\max_{s_i} \alpha b_i s_i - q(s_i)d. \tag{3}$$

where $0 < \alpha < 1$ represents the extent to which the substitute tastes worse than the original. The first order condition dictates that the individual consume up until the point s_i^{**} where

the marginal benefit equals the marginal cost:

$$q'(s_i^{**}) = \frac{\alpha b_i.}{d}. \tag{4}$$

In order for an interior solution to exists, the second order conditions, $p''(s_i) > 0$ and $q''(s_i) > 0$, must be satisfied. Since $p'(s_i) > q'(s_i)$, $p''(s_i) > 0$, and $q''(s_i) > 0$ for all s_i, for a high enough α, $\alpha p'(\cdot) > q'(\cdot)$, and thus $s_i^* < s_i^{**}$. Thus, all individuals consume more of the harmful good if they are consuming it in the form of a softer substitute, as long as the substitute does not taste too much worse than the original. If α is not high enough, $s_i^* > s_i^{**}$. That is, if the substitute tastes much worse than the original, then all individuals consume less of the harmful good if they are consuming it in the form of the substitute. We focus on the case where the substitute does not taste too much worse than the original.

Now consider whether the probability of a bad outcome is greater if individuals are consuming the harmful good in its original form or in the form of its less-harmful substitute, given that they consume more of the good if they are consuming the substitute. Since b_i is continuous, there exists a person $\widetilde{b}$ for whom the following conditions are satisfied:

$$: p'(\widetilde{s^*}) = \frac{\widetilde{b}}{d},\ q'(\widetilde{s^{**}}) = \frac{\alpha\widetilde{b}}{d}, \text{ and } p(\widetilde{s^*}) = q(\widetilde{s^{**}}). \tag{5}$$

Let $f(\cdot)$ and $g(\cdot)$ be the inverse functions of $p'(\cdot)$ and $q'(\cdot)$, respectively. For $b_i > \widetilde{b}$, $s_i^* = f(\frac{b_i}{d}) > \widetilde{s^*} = f(\frac{\widetilde{b}}{d})$, and $s_i^{**} = g(\frac{\alpha b_i}{d}) > \widetilde{s^{**}} = g(\frac{\alpha\widetilde{b}}{d})$. Since $\alpha p'(\cdot) > q'(\cdot)$, $p''(s_i) > 0$, and $q''(s_i) > 0$, we have $s_i^* - \widetilde{s^*} > s_i^{**} - \widetilde{s^{**}}$ and $p(s_i^*) > q(s_i^{**})$. Similarly, $p(s_i^*) < q(s_i^{**})$ for $b_i < \widetilde{b}$. Thus, for those with a sufficiently high taste for the harmful good, the probability of a bad outcome is smaller if they are consuming the substitute. But for those with a lower taste for it, the probability of a bad outcome is greater if they are consuming the substitute.

The substitute directly reduces the probability of a bad outcome holding consumption fixed, but it also indirectly increases the probability of a bad outcome by encouraging more

consumption. The substitute reduces the probability of a bad outcome if and only if the direct effect dominates. The direct effect dominates for people with a sufficiently high taste for the harmful good, because these people would be consuming alot of the harmful good, whether or not it is available in its less-harmful form. On the other hand, the indirect effect dominates for people with a sufficiently low taste for the harmful good, because these people would be consuming the harmful good only if it is available in its less-harmful form.

Light cigarettes and reduced-fat junk food hold the promise of reducing the risks of pulmonary cancer and medical problems related to obesity, such as heart disease. Some people would smoke alot or eat alot of junk food whether or not they had the lighter substitute. For these people, the lighter substitute directly reduces their risks of cancer or heart disease. But other people would smoke alot or eat alot of junk food only if they had the lighter substitute. For these people, the lighter substitute leads them to smoke more or eat more junk food, which increases their risks of cancer or heart disease since the lighter substitute is still harmful. Light cigarettes still contain nicotine, and reduced-fat junk food still contains more fat than healthier foods (and may also contain additional harmful elements).

Now suppose individuals can choose whether to purchase the harmful good in its original form or in the form of its less-harmful substitute, sometime before consuming it. The assumption is that at the time of purchase, their desire for the good is not as great as it is at the time of consumption. Further assuming that the purchase costs of the two forms of the good are about equal, they would choose to purchase the substitute if and only if

$$\begin{aligned} EU_{Subsitute} &= \alpha b_i s_i^{**} - q(s_i^{**})d > EU_{Original} = b_i s_i^{*} - p(s_i^{*})d \qquad (6) \\ &\Leftrightarrow \; b_i(s_i^{**} - s_i^{*}) > (q(s_i^{**}) - p(s_i^{*}))d + (1-\alpha)b_i s_i^{**} \end{aligned}$$

Since $p(s_i^*) > q(s_i^{**})$ for $b_i > \widetilde{b}$, and $q(s_i^{**}) - p(s_i^*)$ for $b_i < \widetilde{b}$, the above condition is more likely to be satisfied for individuals with a high b_i. That is, individuals with a sufficiently high b_i

prefer to use the substitute, knowing that they will not be able to exercise self-control once they have the harmful good in its original form. On the other hand, individuals with a lower b_i prefer to use the original, knowing that they will not be able to exercise self-control once they have the harmful good in the form of its less-harmful substitute. Thus only individuals with a sufficiently high taste for the harmful good purchase the less-harmful substitute.

For people with a sufficiently low taste for cigarettes or junk food, the availability of light cigarettes or reduced-fat junk food increases their consumption of either of these harmful goods sufficiently to increase their risks of cancer or heart disease. If these people are free to choose whether or not to buy the lighter substitute sometime before consuming it, then they would rationally choose not to buy it, in order to ensure self-control and thereby reduce their risks of heart disease or cancer. Therefore, if the time of purchase is sufficiently removed from the time of consumption to allow for self-control, only people with a sufficiently high taste for junk food or cigarettes will actually eat or smoke the lighter substitutes.

3. Other Applications

While the above theory is developed in terms of the impact of substitutes on consumption, it can also be applied to the impact of safety measures on risky behavior, such as sex and speeding. Just as less-harmful substitutes are not always harmless, safety measures, such as condoms and bicycle helmets, are not always full-proof. For this reason, safety measures, like substitutes, have both direct and indirect effects on health outcomes.

Condoms, for example, reduce the risks of unwanted pregnancy and sexually transmitted diseases. Some people would have alot of sex with or without a condom. For these people, condoms directly reduce their risks of a bad outcome. But other people would have alot of sex if and only if they had a condom. For these people, having condoms leads them to have

more sex, which may increase their risks of pregnancy and sexually transmitted diseases since condoms are only effective if used properly, and can also tear by accident. If these people were able to choose whether or not to have a condom some time before they have sex, then they would rationally choose not to have it, in order to ensure self-control and thereby reduce their risks of a bad outcome, with the result that only people with a sufficiently high taste for sex would use condoms.

4. Discussion

We have developed a simple theory of the impact of less-harmful substitutes and partially effective safety devices on consumption and health outcomes. The theory predicts that (1) all individuals consume more of the harmful good (engage more in the risky activity) if they are consuming it in its less-harmful form (doing it with the safety device), (2) consuming the less-harmful substitute (using the safety device) leads to better outcomes for individuals whose taste for the harmful good (risky activity) is sufficiently strong, but to worse outcomes for individuals whose taste for it is weaker, and (3) if individuals can exercise self-control, then only the individuals whose taste for the harmful good (risky activity) is sufficiently strong will use the less-harmful substitute (safety device).

Predictions (1) and (2) may have implications for the FDA regulation of consumption substitutes, as well as for the general regulation of safety measures. The predictions suggest that if a majority of the population has a sufficiently low taste for the harmful good or risky activity, then introducing the less-harmful substitute or partially effective safety measure might actually increase health problems or accidents in the population.

The predictions may also be empirically testable. For example, one could test prediction (1) with aggregate data on Coca Cola consumption in the US. The prediction is that the

total amount of Coke consumed rose significantly when the Coca Cola Company introduced Diet Coke in 1982. Some of the increase would be due to regular Coke drinkers switching to Diet Coke, and drinking more Diet Coke than they were drinking regular Coke; and some of the increase would be due to people who started drinking Coke only when the diet version became available. One could also test prediction (3) with individual-level data on Coke consumption before and after 1982. The prediction is that individuals who consumed alot of Coke before 1982 were more likely to switch to Diet Coke after it was introduced than people who consumed relatively less Coke before 1982.

One might also be able to use prediction (2) of the theory to identify a population's distribution of tastes for a harmful good or risky activity. One could, for example, obtain data on school condom availability programs and abortion rates among teenagers at the school level. According to the prediction, condoms should reduce abortions among those teens whose taste for sex is sufficiently high, but they should increase abortions among those whose taste for sex is sufficiently low. Therefore, if one observed that exogenous variation in condom usage reduces abortions in the teenage population (controlling for other causal factors), then one could conclude that a substantial subset of that population has a relatively high taste for sex. If one observed that condom usage increases abortions, then one could conclude that the teenage population has a relatively lower taste for sex.

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