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Some Fundamental Problems in Becker, Grossman and Murphy's Implementation of Rational Addiction Theory

Abstract:
The econometric implementation of rational addiction theory has been highly influenced by Becker, Grossman and Murphy (BGM). They specify an Euler equation where current consumption is determined by current price and past and future consumption. This model is claimed to be able to discriminate between rational addictive, myopic addictive, and non-addictive behavior. However, as demonstrated in this paper, the coefficients of the Euler equation are not structural parameters. Provided that two implausible assumptions do not hold, the Euler equation coefficients for the rational addict are shown to be non-constant. But even when these assumptions are assumed to be valid, the coefficients of the Euler equation will vary under the alternative hypothesis of myopic addiction. Moreover, and in contrast to the common interpretation, BGM's non-addicted consumer is influenced by past consumption, implying that a rational and a myopic non-addict behave differently. These problems makes it unclear how analyses based on the BGM approach can support, or reject, rational addiction theory.

Keywords: Rational addiction, Euler equation

JEL classification: D11, D12, I10

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1. Introduction

In their influential study, Becker, Grossman and Murphy (1994) [2] (abbreviated as BGM) introduced an empirical implementation of rational addiction theory. They offered an Euler equation where current consumption is expressed as a function of past consumption, current price, but also future consumption. An attractive feature of their approach is that the hypotheses of rational addiction, myopic addiction, and non-addiction can be distinguished using standard statistical tests for the coefficients in the Euler equation. The BGM approach has influenced a large number of papers, ranging from direct applications to studies with extensions in various directions, e.g. Pacula [8], Labeaga [4], Baltagi and Griffin [1], and Gruber and Köszegi [3].

Previous studies seem to have ignored some basic flaws in the BGM approach. First, not all coefficients in the Euler equation are structural parameters. Some of the coefficients which BGM treat as constants are logically functions of prices, and hence, act as endogenous variables for units facing different sets of prices. Even for a single consumer, coefficient constancy relies on the assumption that the consumer perfectly foresees future prices, not only one period ahead, but in all future periods. Second, myopic behavior implies coefficient variability, also when the assumption of perfect foresight holds. Third, the choices of a non-addicted consumer are influenced by past consumption, and a myopic and a rational non-addict will behave differently.

These problems make standard statistical methods for testing the hypothesis of rational addiction against the alternatives inappropriate. It is unclear how results from analyses based on the BGM approach can be taken as evidence for, or against, rational addiction theory. All problems are fundamental logical problems, in the sense that their presence do not depend on the existence of statistical problems such as multicollinearity, measurement errors, or small samples.

2. A summary of the BGM approach

BGM choose a discrete time framework and assume that the instantaneous utility function is quadratic and concave with the form

$$(1)\quad U(y_t, c_t, c_{t-1}) \;=\; \frac{u_{yy}}{2}y_t^2 \;+\; \frac{u_{11}}{2}c_t^2 \;+\; \frac{u_{22}}{2}c_{t-1}^2 \;+\; u_{1y}y_t c_t \;+\; u_{2y}y_t c_{t-1} \;+\; u_{12}c_t c_{t-1},$$

where y_t and c_t is consumption of a composite non-addictive commodity and the addictive commodity in period t, respectively. A life-cycle variable, e_t, which enters in their instantaneous utility function is omitted, since it is not needed for the discussion here. The rational addict faces the intertemporal maximization problem

$$(2)\qquad \max_{(c_1,c_2,\ldots),(y_1,y_2,\ldots)} \sum_{t=1}^{\infty} \beta^{t-1} U(y_t, c_t, c_{t-1}) \quad s.t. \quad \sum_{t=1}^{\infty} \beta^{t-1}(y_t + P_t c_t) = A_0,$$

where c_0 is given, P_t is the price of the addictive commodity – the non-addictive commodity is taken as numeraire – A_0 is the present value of wealth, and the subjective discount factor, β, is assumed to be equal to the market discount factor. Effects of consumption on the present value of wealth or the length of life are ignored. The first order conditions are

$$(3)\qquad \frac{\partial U\left(y_t, c_t, c_{t-1}\right)}{\partial y_t} = \lambda, \qquad t = 1, 2, \ldots,$$

$$(4)\qquad \frac{\partial U\left(y_t, c_t, c_{t-1}\right)}{\partial c_t} + \beta \frac{\partial U\left(y_{t+1}, c_{t+1}, c_t\right)}{\partial c_{t-1}} = \lambda P_t, \quad t = 1, 2, \ldots,$$

where λ is the Lagrange multiplier of the intertemporal budget constraint, that is, the marginal utility of wealth.

The structural part of BGM's econometric Euler equation is obtained by solving the first order condition for y_t, and inserting the result for y_t (and y_{t+1}) in the first order condition for c_t,

$$(5)\qquad c_t = \theta_0 + \theta c_{t-1} + \beta\theta c_{t+1} + \theta_1 P_t, \quad t = 1, 2, \ldots,$$

where

$$\theta_0 = \frac{-(u_{1y} + \beta u_{2y})\lambda}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)}, \tag{6}$$

$$\theta = \frac{-(u_{12}u_{yy} - u_{1y}u_{2y})}{(u_{11}u_{yy} - u_{1y}^2 + \beta(u_{22}u_{yy} - u_{2y}^2))}, \tag{7}$$

$$\theta_1 = \frac{u_{yy}\lambda}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)}. \tag{8}$$

BGM suppress the constant term θ_0, but as it has some relevance for the points to be made, I will include it.

3. BGM's Euler equation coefficients are not structural parameters

BGM seem to ignore the fact that θ_0 and θ_1 are functions of prices in all periods. Both of these coefficients depend on the optimal value of λ, cf. (6) and (8), which obviously is a function of prices in all periods. An example can be found in an appendix where they derive price effects based on the solution to the Euler equation when interpreted as a difference equation. It is easy to verify that in their expressions for derivatives of consumption with respect to prices, θ_1 enters as a constant and not as a function of the price path. Except for being a symptom of a flawed interpretation, this is a correctable formal problem which is not severe.

The erroneous interpretation of the Euler equation has more important consequences in empirical applications. Across a panel of observation units – persons, states, or countries – the coefficients will be different, unless the price paths are identical for all units. But there are interpretational problems in single time series also. Suppose we were to estimate the Euler equation using a data set covering a period in which a large tax hike increased the price of the addictive good. Then, the coefficients in the Euler equation would depend on whether the price increase was anticipated or not. If all assumptions are satisfied, the price hike would have been anticipated and all would have been fine. But if the price hike was unanticipated, the coefficients in the Euler equation would have shifted. Should one allow the coefficients to shift in estimations, or simply assume that they are constants? The latter alternative would have been valid only if the price change had been perfectly

anticipated in a distant past, and by choosing this alternative we impose rationality as an *a priori* restriction. The situation is likely to be even more difficult when price changes occur frequently, which often is the case in non-experimental data.

A second unrealistic assumption in the BGM approach is that the subjective rate of discounting equals the market rate, and that both are constant. Allowing the subjective rate to vary over time raises questions with respect to the consumers' ability to form time-consistent plans. I will not discuss the different aspects of such questions, as they have been treated thoroughly elsewhere, see Strotz [11], Laibson [5], O'Donoghue and Rabin [6], Gruber and Köszegi [3], and Orphanides and Zervos [7], to only mention a few. Instead, assume that the subjective and the market rate of discounting are constants, but not equal, and denote them by β and γ, respectively. If we let γ replace β in the budget constraint in (2) and follow the same procedure when deriving the Euler equation, we find that (6) and (8) are replaced by

$$\theta_{0t} = \theta_0 = \frac{-(u_{1y} + \beta u_{2y})\left(\frac{\gamma}{\beta}\right)^{t-1}\lambda}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)}, \tag{9}$$

$$\theta_{1t} = \theta_1 = \frac{u_{yy}\left(\frac{\gamma}{\beta}\right)^{t-1}\lambda}{(u_{11}u_{yy} - u_{1y}^2) + \beta(u_{22}u_{yy} - u_{2y}^2)}. \tag{10}$$

These coefficients are clearly period specific, making it hard to interpret BGM's estimation results, unless one firmly believes that the market and the subjective discount rates are equal and constant. Needless to say, the interpretation is even harder in situations where the market discount rate is not a constant.

4. BGM's myopic agent is not time consistent, which implies coefficient variability

In order to test the rational addiction theory, at least one non-rational alternative hypothesis is needed. BGM introduce the alternative of myopic agents and relates it to the rational addiction model in the following way:

> "To maintain as much similarity to the previous model as possible, we use the same utility function and the same assumptions about the goods [y]

> and $[c]$. The key distinction is that myopic individuals fail to consider the impact of current consumption on future utility and future consumption. Analytically, this corresponds to individuals using a first order condition that does not contain the future effect $[\beta \times \partial U\left(y_{t+1}, c_{t+1}, c_t\right) / \partial c_{t-1}]$." *(BGM p. 400)*
>
> "Myopic behavior implies that the coefficient on [...] future consumption should be zero, while the rational model implies that it should have the same sign as the coefficient on lagged consumption." *(BGM p. 401)*

BGM do not offer a fully formal definition of myopia, so an interpretation is needed. They refer to Pollak [9] [10], which basically modify static demand or utility functions to allow past consumption to affect current behavior. According to Pollak's approach, the consumer is not fully rational and does not solve a full intertemporal problem. Instead, she solves a sequence of static one-period problems, where the influence of today's consumption on future periods' tastes is not accounted for. A reasonable interpretation of BGM's informal definition, which has similarities with Pollak's approach, is that the myopic agent (erroneously) believes that her instantaneous utility function will be independent of the consumption of the addictive good, but that in all other respects, she is identical to the rational addict. Formally, the maximization problem she solves is then

$$\max_{(c_1,c_2,\ldots),(y_1,y_2,\ldots)} \sum_{t=1}^{\infty} \beta^{t-1} U(y_t, c_t; c_0) \quad s.t. \quad \sum_{t=1}^{\infty} \beta^{t-1}(y_t + P_t c_t) = A_0, \tag{11}$$

where c_0 is regarded as a constant over all periods (in contrast to the rational addiction case above). It is straightforward to show that the first order conditions of this problem are similar to the conditions of the rational addict, except that the term $\beta \times \partial U\left(y_{t+1}, c_{t+1}, c_t\right) / \partial c_{t-1}$ is omitted.[1]

But this is not the full story. Following the same procedure as for the rational addict, we obtain the Euler equation

$$c_t = \tilde{\theta}_0 + \tilde{\theta} c_0 + \tilde{\theta}_1 P_t, \quad t = 1, 2, \ldots, \tag{12}$$

[1]Other authors in the rational addiction literature relate the term "myopia" to the discount function, e.g. assume an infinite subjective interest rate. However, this does not fit neither Pollak's approach nor BGM's informal definition and claimed consequences.

where

$$\tilde{\theta}_0 = \frac{-u_{1y}\lambda}{u_{11}u_{yy} - u_{1y}^2}, \tag{13}$$

$$\tilde{\theta} = \frac{-\left(u_{12}u_{yy} - u_{1y}u_{2y}\right)}{u_{11}u_{yy} - u_{1y}^2}, \tag{14}$$

$$\tilde{\theta}_1 = \frac{u_{yy}\lambda}{u_{11}u_{yy} - u_{1y}^2}. \tag{15}$$

In agreement with BGM's claims, future consumption does not enter in (12). But compared with (5), past consumption is replaced with c_0. Since c_0 is a constant for all future periods, the Euler equation seems degenerated, and variation in current consumption is explained only by changes in current price.

However, if the myopic agent is allowed to reconsider her plans later on, she will not stick to the original plan.[2] A rational addict, on the other hand, will always stick to the original plan as long as the original expectations are fulfilled and the other assumptions are satisfied. Suppose the myopic agent chooses c_1 in the first period, then the optimal plan, as viewed from the second period would solve

$$\max_{(c_2,c_3,\ldots),(y_2,y_3,\ldots)} \sum_{t=2}^{\infty} \beta^{t-1} U(y_t, c_t; c_1) \quad s.t. \quad \sum_{t=2}^{\infty} \beta^{t-1}(y_t + P_t c_t) = A_1, \tag{16}$$

where A_1 is the remaining present value of wealth, evaluated in the second period. This would yield a solution different from (11), unless c_0 and c_1 accidentally are identical. Similarly, the optimization problem in succeeding periods will be updated, and in each period the consumption in the previous period is regarded as a fixed constant in the instantaneous utility function.[3] The Euler equation describing the actually followed consumption path, which is updated accordingly, is not degenerated and can be written

[2] If she is not allowed to reconsider her plans, she will be forced to be time consistent. Then, since she is not addicted in the first period, there will be no way to identify her addiction by only observing her consumption path.

[3] This behavior seems quite irrational. The consumer is able to correctly solve and update the intertemporal optimization problem, but she never realizes that it is past consumption which causes the need for updating the previously formed plans. Such irrationality was common in several habit formation models prior to the rational habit – and rational addiction – models.

as

$$c_t = \tilde{\theta}_{0t} + \tilde{\theta} c_{t-1} + \tilde{\theta}_{1t} P_t, \quad t = 1, 2, \ldots. \tag{17}$$

An important distinction of (17) from the corresponding equation for the rational addict (5), is that $\tilde{\theta}_{0t}$ and $\tilde{\theta}_{1t}$ are not constants. They depend on λ, which will vary as time goes by, since the myopic addict fails to follow a time consistent consumption path

5. BGM's non-addict is influenced by past consumption, which makes a rational non-addict and a myopic non-addict behave differently

BGM also consider the alternative hypothesis that both commodities are non-addictive, where addiction is defined and related to θ in the Euler equation in the passage:

> "... a good is addictive if and only if an increase in past consumption leads to an increase in current consumption holding current prices [...] and the marginal utility of wealth fixed. [...] This definition means that a good is addictive if $\theta > 0$" *(BGM p. 399)*

Strictly interpreted this statement implies that if $\theta \leq 0$, the good is non-addictive. For the present purpose, it is sufficient to consider the case when θ is exactly equal to zero, that is when $u_{12}u_{yy} = u_{1y}u_{2y}$. Let $U_0(y_t, c_t, c_{t-1})$ denote the instantaneous utility function in this case, and let it replace the instantaneous utility functions in (2), (11), and (16). The situation, and the results, are mainly as described in the previous section, except that both in the rational addiction and in the myopic addiction case, the coefficients on future and past consumption are zero. As before, the remaining constant term and the coefficient on current price will vary in the myopic case, when the consumer is allowed to revise her plans.

6. Discussion

The discussion in BGM suggest that myopic addiction and non-addiction can be tested by standard tests on coefficients:

> "the positive and significant past consumption coefficient is consistent with the hypothesis that cigarette smoking is an addictive behavior. The

> positive and significant future consumption coefficient [...] is consistent with the hypothesis of rational addiction and inconsistent with the hypothesis of myopic addiction" *(BGM p. 407)*

But as shown above, the hypotheses of rational addiction, myopic addiction and non-addiction are not neatly nested. Given that the assumption of perfect foresight holds, the coefficient on future consumption is zero in the Euler equation of a myopic agent, whereas the constant term and the coefficient on current price will vary. For a non-addicted consumer, both the coefficients on past and future consumption are zero, and for the myopic non-addict, the constant term and the coefficient on current price will vary. If unforeseen price changes occur, the constant term and the coefficient on current price will change, for all types of agents considered here. Standard tests of significance rely on the assumption that all coefficients under test are constant parameters under the alternative hypothesis. Since this assumption is not valid in the BGM approach, a different testing scheme is required. As long as this lacuna is present, results from analyses based on the BGM approach can hardly be held as evidence for, or against, rational addiction theory.

Finally, a frequent misconception is that the rational addict takes future prices into account, but that the myopic agent does not. This may stem from a passage in BGM, probably referring to the Euler equations of the two agents:

> "Future price (and consumption) changes have no impact on the current consumption of a myopic addict, but they have significant effects on the current consumption of a rational addict." *(BGM pp. 400–401)*

It is clear that an addict behaving according to the rational addiction theory is perfectly able to handling any anticipated price change. But there is nothing in BGM's definitions that make the myopic addict less capable. In fact, when one correctly interpret the Euler equation coefficients as functions of prices, and not constants, it is obvious that a myopic agent's current consumption is influenced by future prices.

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