On Intertemporal Dependent Preferences with regard Environmental Goods and Services

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Abstract

This note extends the standard theory of intertemporal consumer preferences with regard environmental goods and services. It proposes an intertemporal dependent preferences framework that generates a "persistence effect" consistent with consumer's environmental friendly behaviours. Given the present civilizational and cultural pattern of preferences, consumers need to endure a learning-by-consuming process to full enjoy (and use) them, in order to commit himself with "green-economic behaviors"

The contribution to the existing literature is two fold. First we consider the presence of habit-formation with regard the consumption of environmental goods and services in a two goods framework.

Secondly, we establish a consistent preference structure that displays a bounded adjacent complementarity in the consumption of environmental goods and services and present the correspondent properties that need to bee fulfilled by the utility function.

These extensions will allow new advances in environmental economics, especially in the complete characterization of the demand for environmental goods and services and for the sustainable growth debate.

KEYWORDS: Consumer behavior, Intertemporal dependent preferences, Environmental economics.
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1 Introduction

The standard theory of the demand for environmental goods and services (or environmental quality) tends to assume that preferences are intertemporally independent. However, some (if not all) environmental problems (like, for example, CO, CO2, NO2, VOC's[1] emissions attributed, especially, to transportation), can be associated with ("bad") habits of both the consumption of manufactured and environmental goods and services. Surprisingly, it has been hard to find references to this issue in environmental economics, and especially in sustainability.

The effects of habit persistence over the dynamic behavior of consumption along its optimal path were first analyzed by Ryder and Heal (1973). They showed that when instantaneous well-being is determined not only by the current level of consumption (the *level effect*) but also by its (average) past level (the *habit* or *persistence effect*) throughout a process that can be seen as a "learning-by-consuming", the intertemporal dependent preferences might be a sufficient reason to cause a cyclical behavior of consumption along its time path.

The presence of this "*persistence effect*" (whether associated with the consumption of both manufactured or environmental goods and services, or not) raises the question of what should be the role of (environmental) education. Given the current civilizational and cultural pattern of preferences as well as the strength of past consumption habits, it seems reasonable to assume that consumers should undertake a learning-by-consuming process to fully enjoy (and use) environmental goods and services, in order to undergo "green-economic behaviors" compatible with sustainability. This "learning-by-consuming" process can be thought as equivalent to "adjacent complementarity" (see Ryder and Heal (1973) and also Becker and Murphy (1988)). Differently to what is commonly the mainstream of the habit-formation literature, past consumption levels of environmental goods can be viewed as a "*beneficial*" addiction.

To the best of our knowledge, the process of intertemporal dependent preferences with regard to the consumption of environmental goods and its influence over consumer behavior, has not been studied in environmental economics. This note tries to provide some insights into the general context of environmental economics and especially of consumer behavior. In particular, we will extend the existing model of consumer preferences with regard to manufactured and environmental goods by the consideration of a process of habit-formation with regard the environmental goods. We will analyze the structure of intertemporal preferences, which are internally consistent within a two-good framework of consumer choice and, as a consequence, we will propose a utility function whose general properties are consistent with our goals.

2 The general structure of preferences

Consider an economy where the representative household derives utility not only from current consumption from all sort of goods but also he enjoys being "environmentally

[1] V. O. C's - Volatile Organic Compounds

educated ". His problem is to optimally choose the trajectory of consumption of environmental and non-environmental goods, $a(t)$ and $c(t)$, by maximizing the intertemporal utility function

$$U = \int_{t_0}^{\infty} u\left[c(t), a(t), h(t)\right] e^{-\delta t} dt \tag{1}$$

where $\delta > 0$ is the time rate preference and $h(t)$ is the stock of environmental taste at moment t, which is given by

$$h(t) = h(0)e^{-\rho t} + \rho \int_{t_0}^{t} e^{-\rho(t-s)} a(s) ds \tag{2}$$

and were we assume that the rate of learning-by-consuming is equal to the rate of depreciation of the stock of tastes, ρ. This relation can be transformed into it differential form

$$\dot{h}(t) = \rho\left[a(t) - h(t)\right] \tag{3}$$

Let Utility $u(c, a, h)$ exhibit the following properties;

Assumption 1 *Is Increasing with manufactured and both the flow and the stock of the environmental good;* $u_c > 0$, $u_a > 0$*;*

that is, consumer enjoys positive utility by consuming these goods

Assumption 2 *Is concave in all arguments;* $u_{cc} < 0$, $u_{aa} < 0$ *and* $u_{hh} < 0$;

that is, instantaneous marginal utility is decreasing.

Assumption 3 *The environmental good is "beneficial";* $u_h > 0$

The consumer not only drives wellfare with the flow of environmental goods but also enjoys getting environmental education. This assumption clearly contrasts with the main-stream of the habit-formation literature (see, for example, Ryder and Heal (1973), Constantinides (1990), Carroll (2000a), Wendner (2000)) who assumes that $u_h < 0$. We rather follow Becker and Murphy (1988) by assuming that the stock of habits with regard to the environmental good has a positive value for the consumer. To use Becker and Murphy (1988)'s words, past consumption levels of the environmental good is viewed as a "beneficial" addiction; the more the past level of consumption, the less is required to derive the same level of utility in the present, for any given current levels of consumption of both manufactured and environmental goods and of the stock of natural capital.

If we take $t_0 = 0$ as the initial time, then equation (1) defines a following value functional

$$U = \int_{0}^{\infty} u\left[c(t), a(t), \left(h(0)e^{-\rho t} + \rho \int_{0}^{t} e^{-\rho(t-s)} a(s) ds\right)\right] e^{-\delta t} dt \tag{4}$$

Utility functional defined by (4) models the presence of complementarity over time in consumption of environmental goods, in the sense that any unitary change of consumption at time $t = t_1$ has not only an impact on current utility given by the instantaneous marginal utility, but also an impact over the future level of utility, measured

by the intertemporal marginal utility. More formally, if a given path of the consumption of the environmental and of manufactured goods is perturbed at an arbitrary time $t = t_1 > t_0$ from $a = \{a(t), 0 \leq t < +\infty\}$ to $a = \{(a(t) + \alpha(t)), 0 \leq t < +\infty\}$ and from $c = \{c(t), 0 \leq t < +\infty\}$ to $c = \{(c(t) + \gamma(t)), 0 \leq t < +\infty\}$ respectively, then the resulting change in the value of the functional (4) over time can be captured by the following Fréchet derivatives[2]:

$$U_a(.)\alpha = \int_0^{+\infty} \left[u_a(t)\alpha(t) + \rho u_h(t) \int_0^t e^{-\rho(t-s)} h(s) ds \right] e^{-\delta t} dt \tag{5}$$

$$U_c(.)\gamma = \int_0^{+\infty} u_c(t)\gamma(t) e^{-\delta t} dt \tag{6}$$

If we assume a constant unit perturbation near the steady state levels of consumption of both the manufactured and environmental goods, $\overline{c} = \{c(t) = \overline{c},\ 0 \leq t < \infty\}$ and $\overline{a} = \{a(t) = \overline{a},\ 0 \leq t < \infty\}$, then, under assumptions 1, 2 and 3, the two intertemporal marginal utilities are the sum of the present value of the correspondent instantaneous marginal utilities,

$$U_a(\overline{c}, \overline{a}, \overline{h}) = \frac{1}{\delta} \left(\overline{u}_a + \frac{\rho}{\rho + \delta} \overline{u}_h \right) > 0 \tag{7}$$

$$U_c(\overline{c}, \overline{a}, \overline{h}) = \frac{\overline{u}_c}{\delta} > 0 \tag{8}$$

where $\overline{u}_i \simeq u_i\ (\overline{c}, \overline{a}, \overline{n}, \overline{h})$, for $i = c, a, h$. Note that these two magnitudes are positive, meaning that there is no satiation in the consumption of the two goods. On the other hand, the marginal rate of intertemporal substitution between the two goods is given by

$$MRIT_{a,c} = -\left(\frac{\overline{u}_a}{\overline{u}_c} + \frac{\rho}{\rho + \delta} \frac{\overline{u}_h}{\overline{u}_c} \right) < 0 \tag{9}$$

This magnitude is, in absolute value, smaller then its correspondent without the "*inertia effect*". The presence of habits "overweights" the value of environmental goods in relation to the manufactured goods, which implies that any increase in the consumption of manufactured goods need to be compensated by a smaller reduction in the consumption of environmental goods then it would be if habits were ignored, in order to assure the maintenance of the intertemporal flow of utility.

Given our previous assumption about the concavity of the instantaneous utility function, it is easy to see that the intertemporal marginal utility for both goods, along the

[2]The intertemporal marginal utility can be measure by the Volterra derivative which was first introduced in the literature of habit-formation by Wan (1970) and Ryder and Heal (1973). The Volterra derivative is a particular case of the Fréchet derivative in the sense that it measures the impact over the value of the functional **??** when a given path of the consumption good $\{c(t)\}$ is perturbed at any arbitrary time $t = t_1$. In this case, we would get a similar expressions, in which the discount factor would be replaced by the infinite sum of discounted factor $\frac{1}{\delta} = \int_0^{\infty} e^{-\delta t_1} dt$. For more details, see, for example, Brito and Barros (2004).

stationary trajectory is decreasing: a constant increase of the consumption of environmental goods, will increase utility at a decreasing rate.

$$U_{aa}(\overline{c},\overline{a},\overline{h}) = \frac{1}{\delta}\left[\overline{u}_{aa} + \frac{2\rho+\delta}{\rho+\delta}\left(\overline{u}_{ha} + \frac{\rho}{2\rho+\delta}\overline{u}_{hh}\right)\right] < 0 \tag{10}$$

We say that there is learning-by-consuming (or habit-formation) if utility displays bounded adjacent complementarity in the consumption of environmental goods. Any increase in the consumption of the environmental goods is related to recent increases in time, as opposed to distant ones.

Assumption 4 *The process of intertemporal dependent preferences is said to display bounded own adjacent complementarity in the consumption of environmental goods and services, such that*

$$0 < \overline{u}_{ha} + \frac{\rho}{2\rho+\delta}\overline{u}_{hh} < -\left(\frac{\rho+\delta}{2\rho+\delta}\right)\overline{u}_{aa} \tag{11}$$

with the upper bound defined as

$$(\delta+\rho)\,\overline{u}_{aa} + (2\rho+\delta)\,\overline{u}_{ha} + \rho\overline{u}_{hh} \simeq Z < 0 \tag{12}$$

At last, we need to establish the relationships between the two goods on the two dimensions involved in the problem. For simplicity, we will use the most simple structure.

Assumption 5 *There is both own and crossed intertemporal independency in relation to the consumption of manufactured good;* $u_{ch} = 0$.

In other words, the demand for environmental goods is additively separable. The present value of the instantaneous utility does not take into account the lagged effects (see 8). Most importantly, the rate of intertemporal substitution for the environmental good between two moments in time, is independent from the changes of the manufactured good. Conversely, the rate of intertemporal substitution for the manufactured good between two moments in time, is independent from the changes of the environmental good.

3 Intratemporal separable preferences

Weak separability is commonly assumed as a simplifying conjecture in most papers which deals with habit-formation. Given our previous assumptions, not all forms of separability are allowed.

One can consider two basic structures. First, we could consider the most common form of separability in international macroeconomics theories involving habit-formation: the stock-flow separability. In this case we would have $u(\varphi(c,a),\eta(h))$, where $\varphi(.)$ and $\eta(.)$ are weakly separable. Together with our assumptions 1 and 2, this assumption allows for the a simplification of the problem as well as for a simplifying manner to treat the relative prices.

Second, there would be a environmental versus manufactured separability if $u(c, \eta(a, h))$, where c and $\eta(.)$ are weakly separable (that is). In this case $\eta(.)$ need not be assumed to be linearly homogeneous, thought it could be additively separable.

Lemma 1 *Let assumptions 1 to 5 hold. Then $u(c, a, h)$ can only be weakly separable into manufactured and environmental goods, i.e. $u = u(c, m(a, h))$. This is equivalent to assume that*

$$u_{ac} = u_{hc} = 0 \tag{13}$$

and the utility function can be expressed as

$$v = v\,(a, h) + u\,(c) \tag{14}$$

This means that the standard type of separability assumed in the open macroeconomic literature should be excluded. Instead, the quadratic instantaneous utility function assumed by Becker and Murphy (1988) the utility function with multiplicative habits but Carrol et al. (1997) and Carroll (2000b) (with a slight modification) verify those properties. assuming own adjacent complementarity in preferences regarding the environmental goods.

4 Conclusion and final remarks

This note extends the standard theory of intertemporal consumer choice. It proposes an intertemporal dependent preferences framework that might be used to explain the persistence of some consumer's environmental unfriendly behaviours. The contribution to the existing literature is two fold. First we consider the presence of habit-formation with regard the consumption of environmental goods and services in a two goods framework. In contrast with hat is common in the habit-formation literature, this persistence effect is assumed as a "beneficial addition" which "overweight" the value of environmental goods in relation to the manufactured goods.

Secondly, we establish a consistent preference structure that displays a bounded adjacent complementarity in the consumption of environmental goods and services and present the correspondent properties that need to bee fulfilled by the utility function.

We are confident that this extensions will allow new advances in environmental economics, especially in the complete characterization of the demand for environmental goods and services and for the sustainable growth debate.

As Ryder and Heal (1979) showed, when the persistence effect is present in the instantaneous utility then the intertemporal dependent preferences might be a sufficient reason to cause a cyclical behaviour of consumption along its time path. We, then, might be able to get one additional microfundation for the Environmental Kuznets Curve.

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