E C O N O M I C S   B U L L E T I N

Is habitual consumption harmful to the environment?

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Abstract

This paper explores the theoretical linkage between habit and the environment through environmentally harmful consumption affected by habitual behavior. It is shown that habit formation of consumption has both negative and positive effects on environmental quality. Whether the positive effect dominates the negative one depends on the degrees of habit formation and environmental externalities.

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1. Introduction

This paper explores the theoretical linkage between habit and the environment through environmentally harmful consumption affected by habitual behavior, focusing on how habit formation of consumption affects environmental quality, and whether this consumption is harmful to the environment. It is shown that habit formation of consumption has both negative and positive effects on environmental quality. Which effect dominates is dependent on the degrees of habit formation and environmental externalities. Hence, the paper provides a simple condition for evaluating the effect of habitual consumption on environmental quality.

The relation between habitual consumption and the environment has been mainly studied by psychologists; see Fransson and Garling (1999) and the references therein. Psychologists have indicated the possibility that habit formation of consumption increases consumption of luxury or durable goods, such as cars and air conditioners, which creates environmentally harmful emissions. Thus, they concluded that habit formation of consumption would cause environmental deterioration.

They, however, drew this conclusion without using models to explain the relation between habitual consumption and the environment. Hence, from psychological studies, this relationship, and the economic interaction it entails, cannot be known. It is therefore necessary to develop a model of environmentally harmful consumption affected by habitual behavior, and to establish the way in which habitual consumption affects the environment.

There are few economic studies on habit formation and the environment. Wendner (2000a, 2000b) is one such study. Following Lahiri and Puhakka (1998) and a previous report of his own (Wendner (2000c)), he introduced habit formation into two-period overlapping generations models by assuming that a higher first period consumption reduces utility derived from a given level of second period consumption. However, while he focused on the relation between habit formation and the environment, he did not consider this relationship in terms of environmentally harmful consumption.[1] Against such background, this paper addresses that issue, and provides a simple condition for evaluating the effect. This paper would therefore contribute to the

[1] Wendner (2000a) focuses on environmentally harmful production. Wendner (2000b) considers environmentally harmful consumption, but the main focus is on the design of optimal tax schemes; how habit affects environmental quality through consumption is not examined.

literature on consumption and its effect on the environment by clarifying the relation between them.

This paper is organized as follows. Section 2 develops the model and characterizes equilibrium. Section 3 shows the main result. Section 4 provides concluding remarks.

2. The Model

Consider an infinite-horizon economy comprised of two-period-lived overlapping generations. A new generation is born in each period $t = 1, 2, ...$ The size of a newly born generation is normalized to one.

Each generation lives for two periods, youth and old age, and obtains utility from consumption in both periods and environmental quality in old age.[2] However, in the presence of habit formation, utility of a given level of consumption in old age is not independent of consumption in youth. Utility is affected by the absolute level of consumption in old age as well as the increase of consumption in old age relative to that in youth. Let c_t^1 denote consumption of generation t in the first period (youth), c_{t+1}^2 consumption of generation t in the second period (old age), and E_{t+1} environmental quality in period $t+1$. Then, the lifetime utility of an agent in generation t is

$$\frac{(c_t^1)^{1-\theta} - 1}{1-\theta} + \pi \left\{ \frac{(\hat{c}_{t+1}^2)^{1-\theta} - 1}{1-\theta} + \eta \frac{(E_{t+1})^{1-\theta} - 1}{1-\theta} \right\}$$

where $\hat{c}_{t+1}^2 \equiv c_{t+1}^2 - hc_t^1$ is the effective consumption in old age, $\theta(> 0)$ denotes the magnitude of the elasticity of marginal utility with respect to consumption or environmental quality, $\pi(> 0)$ is the subjective discount factor, $\eta(> 0)$ denotes the degree of environmental concern, and $h(> 0)$ denotes the degree of habit formation; a higher h implies a greater intensity of habit formation.[3]

The environment is assumed to be a public good that is reduced by consumption but can be improved by maintenance investment. This mechanism is expressed as the formula:[4]

$$E_{t+1} = E_t - \beta(c_t^1 + c_t^2) + \gamma m_t, \tag{1}$$

[2] As described below, each generation cannot control environmental quality in the period of youth. Thus, it is assumed that environmental quality in youth has no effect on utility.

[3] This form of habit formation follows from Lahiri and Puhhaka (1998) and Wendner (2000c, 2002).

[4] This simple formulation is based on John and Pecchenino (1994) and John et al. (1995).

where $E_t(E_{t+1})$ is the index of environmental quality in period $t(t+1)$, $\beta > 0$ is a parameter of consumption externalities, $c_t^1 + c_t^2$ is the aggregate consumption in period t, $\gamma > 0$ is a parameter that represents the technology for environmental maintenance, and m_t is the aggregate maintenance investment made for the environment in period t. The maintenance activity in period t is conducted by generation t since this generation can enjoy the improved environmental quality in its old age.

Each generation is endowed with $w \in \Re_{++}$ units of a private good when young and with nothing when old. Each generation can access a storage technology with a gross return rate of $R > 0$. If a generation invests one unit of a private good when young, then it can obtain R units when old.[5] Thus, the budget constraint of generation t is $c_t^1 + s_t + m_t = w$ in youth and $c_{t+1}^2 = Rs_t$ in old age where s_t is the amount of investment in a storage technology. These constraints are summarized as the life-cycle budget constraint:

$$c_t^1 + c_{t+1}^2/R + m_t = w. \tag{2}$$

Generation t chooses $\{c_t^1, s_t, m_t\}$ to maximize its utility subject to the life-cycle budget constraint (2) and the environmental equation (1). The first-order conditions which characterize the outcome of generation t are

$$(c_t^1)^{-\theta} = \left(\beta + \gamma + \frac{h\gamma}{R}\right) \pi\eta(E_{t+1})^{-\theta}, \tag{3}$$

$$R(c_{t+1}^2 - hc_t^1)^{-\theta} = \gamma\eta(E_{t+1})^{-\theta}, \tag{4}$$

and (1) and (2) where c_t^2 and E_t are determined by the previous generation.[6]

Eq.(3) states that generation t chooses consumption when young, equating the marginal rate of substitution between consumption in youth and environmental quality in old age to the marginal rate of transformation, $\beta + \gamma + h\gamma/R$. At the utility maximum, a decrease in utility due to falling

[5] The model presented here keeps the production side as simple as possible by adopting a linear storage technology, since our focus is, rather, on the effect of habitual consumption on environmental quality.

[6] The present paper focuses on environmental externalities across generations (i.e., E_t and c_t^2), ignoring externalities within a generation. This is because there have been growing concerns on intergenerational environmental problems; for example, the accumulation of greenhouse gases and the depletion of tropical forests. Such problems are mainly caused by myopic consumption behavior of each generation. Herein such behavior is linked to habitual consumption, and its environmental consequences are considered.

consumption during youth is equal to an increase in utility due to the sum of an increase in maintenance effort, $\gamma(1+h/R)$, and a decrease in a consumption externality, β. Eq.(4) states that generation t chooses savings, equating the marginal rate of substitution between the effective consumption in old age, $c^2_{t+1} - hc^1_t$, and environmental quality in old age to the marginal rate of transformation, γ/R. At the utility maximum, a decrease in utility due to falling consumption during old age, R, is equal to an increase in utility due to an increase in maintenance effort, γ.

The economy starts at $t = 1$. In this period, there are generation 1 and the initial old agent who lives only in period 1. The initial old agent is endowed with ω units of a private good to consume. The utility of the initial old agent is $\{(c^2_1)^{1-\theta} - 1\}/(1-\theta) + \eta\{(E_1)^{1-\theta} - 1\}/(1-\theta)$ where $c^2_1 = \omega$ and E_1 are given.

It should be noted that the model presented here is based on the models of John and Pecchenino (1994) and John et al.(1995), but differs from theirs in that habit formation of consumption is introduced here. Habit formation would decrease consumption in youth and increase savings (i.e., consumption in old age); the former has a positive effect, whereas the latter has a negative effect on the environment. The environmental consequence of these effects will be considered in the next section.

The remaining task in this section is to characterize an equilibrium, defined as follows. An *equilibrium* is a sequence $\{c^1_t, c^2_t, E_t, m_t\}^{\infty}_{t=1}$ with the initial condition $\{c^2_1, E_1\}$ such that each generation maximizes its utility subject to the budget constraints and the environmental equation. A *steady state equilibrium* is an allocation such that $\{c^1, c^2, E, m\}$ is stationary along the equilibrium path. In particular, the steady state equilibrium levels of consumption and environmental quality, $\{c^1, c^2, E\}$, are characterized by the following three equations:

$$(c^1)^{-\theta} = \left(\beta + \gamma + \frac{h\gamma}{R}\right)\pi\eta(E)^{-\theta}, \tag{5}$$

$$R(c^2 - hc^1)^{-\theta} = \gamma\eta(E)^{-\theta}, \tag{6}$$

$$\beta(c^1 + c^2) = \gamma\left(w - c^1 - \frac{c^2}{R}\right). \tag{7}$$

These three equations lead to the existence and uniqueness of the steady state equilibrium. The next section presents the analysis conducted at this steady state.

3. The Effects of Habit Formation on the Environment

This section examines how habit formation affects the steady state equilibrium level of environmental quality, then discusses the implication of the result for an economy under habit formation.

Proposition 1: *Habit formation improves (harms) environmental quality if and only if* $\theta \lesseqgtr \phi(h)$ *where*

$$\phi(h) \equiv \frac{\frac{\gamma}{R}}{\beta + \frac{\gamma}{R}} \left(1 + \frac{\beta}{\frac{\beta+\gamma}{h} + \frac{\gamma}{R}} \right).$$

That is, $\partial E/\partial h \gtreqless 0$ *if and only if* $\theta \lesseqgtr \phi(h)$*. Moreover,* $\partial c^1/\partial h < 0$ *and* $\partial c^2/\partial h > 0$ *hold* $\forall h \geq 0$.

Proof: Differentiation of (5) - (7) with respect to c^1, c^2, E, and h yields

$$\begin{bmatrix} -\theta(c^1)^{-\theta-1} & 0 & \pi\eta\theta\left(\beta+\gamma+\gamma h/R\right)(E)^{-\theta-1} \\ Rh\theta(\hat{c}^2)^{-\theta-1} & -R\theta(\hat{c}^2)^{-\theta-1} & \theta\gamma\eta(E)^{-\theta-1} \\ \beta+\gamma & \beta+\gamma/R & 0 \end{bmatrix} \begin{bmatrix} dc^1 \\ dc^2 \\ dE \end{bmatrix}$$
$$= \begin{bmatrix} \pi\eta\gamma(E)^{-\theta}/R \\ -\theta Rc^1(\hat{c}^2)^{-\theta-1} \\ 0 \end{bmatrix} dh.$$

It is immediately shown that the determinant of the left-hand side matrix is positive. Let $|D|$ denote the determinant. By Cramer's rule,

$$\frac{\partial E}{\partial h} = \frac{R\theta\pi\eta}{|D|\,(\hat{c}^2)^{\theta+1}(E)^{\theta}} \left[\frac{\gamma}{R}(\beta+\gamma) - \theta\left(\beta+\gamma+\frac{\gamma h}{R}\right)\left(\beta+\frac{\gamma}{R}\right) + h\frac{\gamma}{R}\left(\beta+\frac{\gamma}{R}\right) \right].$$

Thus, we obtain $\partial E/\partial h \gtreqless 0$ if and only if $\theta \lesseqgtr \phi(h)$. We also obtain $\partial c^1/\partial h < 0$ and $\partial c^2/\partial h > 0$ $\forall h \geq 0$ by using Cramer's rule. **Q.E.D.**

Figure 1 depicts the relation between θ and $\phi(h)$. The function $\phi(h)$ is strictly increasing and strictly concave in h with $\lim_{h\to 0}\phi(h) = (\gamma/R)/(\beta + \gamma/R) < 1$ and $\lim_{h\to+\infty}\phi(h) = 1$. If $\theta \geq 1$, then $\partial E/\partial h < 0$ $\forall h \geq 0$; that is, habit formation is always harmful to the environment. On the other hand, if $\theta < (\gamma/R)/(\beta + \gamma/R)$, then $\partial E/\partial h > 0 \forall h > 0$; that is, habit formation is always beneficial to the environment. Finally, if $\theta \in [(\gamma/R)/(\beta + \gamma/R)$

, 1), the initial value of h is important in determining the impact of habit formation on the environment. Given θ, there exists a critical level of h, $\tilde{h}(\theta)$, such that $\partial E/\partial h \gtreqless 0$ if and only if $h \gtreqless \tilde{h}(\theta)$.

Habit formation has effects on environmental quality in two directions through consumption. First, a higher h leads to a smaller amount of consumption in youth: this has a positive effect on the environment. Second, a higher h leads to a larger amount of savings, and, consequently, a larger amount of consumption in old age: this has a negative effect on the environment. Whether the positive effect overcomes the negative one depends on parameter values in the inequality condition $\theta \lesseqgtr \phi(h)$.

When the inequality $\theta \leq (\gamma/R)/(\beta + \gamma/R)$ holds, habit formation is always beneficial to the environment. This inequality requires small β and R, given θ and γ. Although habit formation affects consumption, its effect on the environment is inconsiderable due to a small value of β. In addition, habit formation leads to an increase of consumption in old age, but varies only to a minor degree since the return on saving, R, is low: this gives a weak effect on the environment. Due to these two effects, the positive effect of habit formation is always greater than the negative one. Therefore, habit formation improves environmental quality if $\theta \leq (\gamma/R)/(\beta + \gamma/R)$.

When the inequality $\theta > (\gamma/R)/(\beta+\gamma/R)$ holds, the opposite result may occur. The inequality requires large β and R, implying a greater effect on the environment through consumption. In particular, the negative effect of habit formation is always greater than the positive one when $\theta \geq 1$ holds. When $\theta \in ((\gamma/R)/(\beta + \gamma/R)\ , 1)$, the initial degree of habit formation plays a key role in determining the effect. We can evaluate the effect by using the condition $\theta \lesseqgtr \phi(h)$, which is rewritten as $h \gtreqless \tilde{h}(\theta)$ where $\tilde{h}(\theta)$ satisfies $\theta = \phi(h)$. When the initial value of h is below the critical level $\tilde{h}(\theta)$, a marginal increase in h has a strong effect on the environment; thus, a greater intensity of habit formation leads to a lower quality environment. On the other hand, when the initial value of h is above the critical level, a marginal increase in h has a weak effect on the environment; thus, a greater intensity of habit formation leads to a higher quality environment.

The result suggests that when $\theta \in ((\gamma/R)/(\beta+\gamma/R)\ , 1)$ holds, there exists another critical level of the degree of habit formation, $\hat{h}(\theta)(> \tilde{h}(\theta))$, such that $E|_{h=0} \gtreqless E|_{h>0}$ holds if and only if $h \lesseqgtr \hat{h}(\theta)$ (see Figure 2). That is, if the initial degree of habit formation h is greater (less) than the critical level $\hat{h}(\theta)$, then the environmental quality without habit formation, $E|_{h=0}$, is less (greater) than the quality under the presence of habit formation, $E|_{h>0}$. For a higher (lower) degree of habit formation, the economy experiences a higher (lower) quality environment relative to the economy without habit formation. Thus, the presence of habitual consumption behavior is not necessarily harmful to the environment. A strong intensity of habit formation may be desirable from the viewpoint of environmental preservation.

4. Concluding Remarks

This paper has considered the effect of habit formation on environmental quality in a two-period overlapping generations model in which (i) habit formation is assumed such that higher first-period consumption reduces the utility from a given level of second-period consumption, and (ii) environmental quality is reduced by consumption. Under this framework, the paper has shown that whether habitual consumption is harmful to the environment depends on the degrees of habit formation and environmental externalities of consumption. Thus, this paper has provided a simple condition for analyzing environmental consequence of habit formation.

The present paper is closely related to the paper by Wendner (2000a), who showed that, in most cases, habit formation of consumption is harmful to the environment. The result shown in Proposition 1, which differs from that in Wendner (2000a), is derived from the following two assumptions that differ from him. First, his paper assumes that environmental quality is reduced by *production,* whereas this paper assumes that it is reduced by *consumption.* Second, Wendner (2000a) focuses on the behavior of an atomistic *agent* who does not take care of the environment, whereas this paper focuses on a representative agent (i.e., a *generation)* who takes care of the environment. Thus, the analysis of this paper focuses on the effect of generations' behavior on environmental quality rather than on that of atomistic agents' behavior as analyzed in Wendner (2000a). Based on the two different presumptions used here, this paper could present a new aspect of habit formation and environmental quality.

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Figure 1

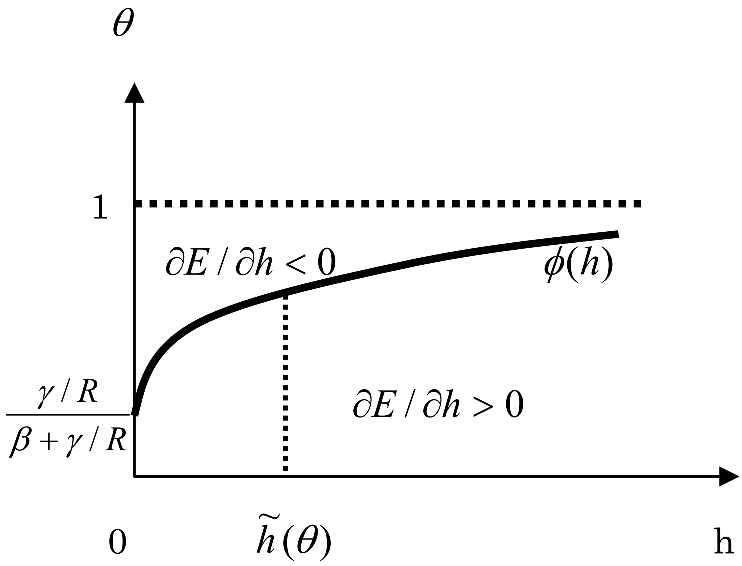

Figure 2