Myopia and the economics of nonrenewable resources

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Abstract

The paper focuses on the problem of limited natural resources by examining a dynamic framework in which the total life-time amount of consumption is fixed. The problem is studied separately for logarithmic and exponential utility, and separately for nonmyopic and myopic preferences. The sensitivity of utility to the degree of myopia is in relative terms higher for exponential than for logarithmic utility.

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1 Introduction

One of the biggest problems in the real world is the fact that the stocks of natural resources are limited. Unless oil, natural gas, and coal are replaced with some other sources of energy, economic hardship will be inevitable in a relatively near future. The problem of limited nonrenewable resources really matters. Myopia may play an important role in the problem of limited resources.

The issue of myopia and related topics has been discussed relatively extensively in the economic literature. Some aspects of myopia in the context of the permanent income hypothesis are examined by Flavin (1985). Stein (1989) develops a model in which he studies consequences of the myopic behavior of firm managers. Dresch (1990) considers the three cases of weighting the present and the future - myopia (the preference of the present relative to the future), emmetropia (the correct relative weighting of the present and the future), and hypermetropia (the preference of the future relative to the present). His study finds some evidence that hypermetropia is more important than myopia in primary resource markets. Loewenstein and Prelec (1992) present important examples of discounted utility anomalies and discuss implications for savings behavior and the estimation of discount rates. Barro (1997) develops a neoclassical growth model with a non-constant rate of time preference. He studies the cases with no commitment and partial commitment regarding future consumption choices. Lambrecht, Michel, and Thibault (2000) discuss a concept of myopic altruism in a model in which income (instead of utility) of the future generation enters the utility of the present generation. Scaramozzino and Marini (2000) justify the necessity to have a positive social rate of time preference.

The present paper tries to provide a simple dynamic model of limited resources. The model is very simple in that there is no production: natural resources are directly used for consumption. Using the principle of variations, the model is solved for nonmyopic and myopic preferences. Instantaneous utility is assumed to be logarithmic and exponential. In all cases, consumption decreases over time in the optimum. Although this fact is typically not observed in the real world, it will become reality in the future if we do not manage to find alternative sources of energy. An interesting feature of the model is that the total discounted utility may be increasing in the rate of time preference. A higher rate of time preference leads to a shift of consumption from the future to the present; a higher level of utility at present and in the near future may outweigh the lower level of utility in the distant future. In absolute terms, the sensitivity of utility to changes in the rate of time preference is high for logarithmic utility. As expected, initial consumption is higher for myopic than for nonmyopic preferences. The total discounted utility is lower for myopic than for nonmyopic preferences. The paper focuses on examining the sensitivity of the total discounted utility to the degree of myopia. In relative terms, this sensitivity is not very high for logarithmic preferences, but it is higher for exponential preferences. It is thus possible, although not inevitable, that myopia matters for the expected well-being of humanity.

2 Logarithmic utility

There is no production. The total life-time integrated amount of consumption is fixed at the level of $\tilde{C}$. For the logarithmic utility, the problem is

$$u = \max_C \int_0^T \ln C e^{-\rho t} dt$$

subject to

$$\int_0^T C dt = \tilde{C}, \tag{1}$$

where C is the flow of consumption, T is the length of life, and ρ is the rate of time preference. The problem can be solved using the principle of variations (see, for example, Brdicka and Hladik, 1987, Appendix II). The Lagrangian for this problem is

$$\mathcal{L} = e^{-\rho t} \ln C + \lambda C. \tag{2}$$

Since the Lagrangian is not a function of the time derivative of C, the Lagrange-Euler equation takes a simple form

$$\frac{\partial \mathcal{L}}{\partial C} = 0. \tag{3}$$

From this it follows that

$$C = C_0 e^{-\rho t}. \tag{4}$$

The initial level of consumption, C_0, is given from equation (1) by

$$C_0 = \frac{\tilde{C}\rho}{1 - e^{-\rho T}}. \tag{5}$$

The derivative of C_0 with respect to ρ is positive for a sufficiently high T. If T tends to ∞, then $C_0 = \tilde{C}\rho$. The total discounted utility is equal to

$$u = (e^{-\rho T} - 1)(1 - \ln C_0)/\rho + T e^{-\rho T}. \tag{6}$$

If $T \to \infty$, the discounted utility tends to

$$u = (\ln C_0 - 1)/\rho = [\ln(\tilde{C}\rho) - 1]/\rho. \tag{7}$$

$$\frac{\partial u}{\partial \rho} = \frac{2 - \ln(\tilde{C}\rho)}{\rho^2} \tag{8}$$

Continue to assume that $T \to \infty$. Thus the total utility is increasing in ρ if $\tilde{C}$ and ρ are sufficiently small. An increase in ρ is associated with a shift of consumption from the future to the present. The gain of utility at present and in the near future may outweigh the decrease of utility in the distant future (the distant future is more affected by the higher discounting). In the extreme situation with no discounting, the total utility is infinitely negative. If $\tilde{C} = 1$, then $u = -560.5$ for $\rho = 0.01$, $u = -245.6$ for $\rho = 0.02$, $u = -150.2$ for $\rho = 0.03$, and $u = -105.5$ for $\rho = 0.04$. Thus utility is sensitive to variations in ρ. This sensitivity does not depend on the choice of $\tilde{C}$.

The analysis above corresponds to nonmyopic preferences. Let us now introduce myopia in the sense that people are infinitely lived but form their consumption choices based on the existing remaining stock of consumption (C_R) as if they were facing a time period T' before the end of the world. Initially, $C_R = \tilde{C}$. At any point in time, it holds that

$$\dot{C}_R = -C, \tag{9}$$

$$C = \frac{C_R \rho}{1 - e^{-\rho T'}}. \tag{10}$$

These equations lead to a differential equation for C_R:

$$\dot{C}_R = -C_R \frac{\rho}{1 - e^{-\rho T'}}, \tag{11}$$

the solution of which is

$$C_R = \tilde{C} e^{-\rho/(1-e^{-\rho T'})t}, \tag{12}$$

$$C = \frac{\tilde{C}\rho}{1 - e^{-\rho T'}} e^{-\rho/(1-e^{-\rho T'})t}. \tag{13}$$

For this solution, the total discounted utility is

$$u = \left(\ln \frac{\tilde{C}\rho}{1 - e^{-\rho T'}} - \frac{1}{1 - e^{-\rho T'}} \right) / \rho. \tag{14}$$

T' is the inverse degree of myopia. The total discounted utility depends positively on T' because $f(x) = \ln(\tilde{C}\rho x) - x$ is decreasing in x for $x > 1$. The total discounted utility is not very sensitive to T' unless T' is very small. For example, let $\tilde{C} = 1$ and $\rho = 0.02$. Then $u = -245.6$ for $T' \to \infty$, $u = -256.6$ for $T' = 40$, $u = -291.8$ for $T' = 20$, and $u = -386.0$ for $T' = 10$.

3 Exponential utility

The problem is

$$u = \max_C \int_0^T -\frac{1}{\Theta} e^{-\Theta C} e^{-\rho t} dt$$

subject to (1). Θ is a positive parameter. The Lagrange-Euler equation leads to

$$C = C_0 - \frac{\rho}{\Theta} t, \tag{15}$$

where

$$C_0 = \frac{\tilde{C}}{T} + \frac{\rho T}{2\Theta}. \tag{16}$$

Consumption must always be nonnegative, which leads to the condition

$$\tilde{C} \geq \frac{\rho T^2}{2\Theta}. \tag{17}$$

The total discounted utility in this nonmyopic case is

$$u = -\frac{1}{\Theta} e^{-\Theta \tilde{C}/T - \rho T/2} T. \tag{18}$$

Utility is finite (nonpositive) and increasing in ρ. If T tends to infinity, utility goes to zero. C_0 is increasing in ρ. Let us consider the following specification: $T = 1000$ (years), $\rho = 0.02$, $\Theta = 1$, and $\tilde{C} = \frac{\rho T^2}{2\Theta} = 10000$. Then $u = -2.06\ 10^{-6}$. The total discounted utility is $-2.51\ 10^{-5}$ for $\rho = 0.015$, $-3.06\ 10^{-4}$ for $\rho = 0.01$, and -0.05 for $\rho = 0$. Utility is sensitive to ρ in relative terms.

If there is myopia (people looking ahead for the period $T' << T$), consumption satisfies

$$C = \frac{C_R}{T'} + \frac{\rho T'}{2\Theta}, \tag{19}$$

$$C = -\dot{C}_R, \tag{20}$$

$$\dot{C}_R = -\frac{C_R}{T'} - \frac{\rho T'}{2\Theta}, \tag{21}$$

$$C_R = \left(\tilde{C} + \frac{\rho T'^2}{2\Theta}\right) e^{-t/T'} - \frac{\rho T'^2}{2\Theta}, \tag{22}$$

$$C = \left(\frac{\tilde{C}}{T'} + \frac{\rho T'}{2\Theta}\right) e^{-t/T'}. \tag{23}$$

C_R cannot be negative. When $C_R = 0$, $C = 0$ from this time point till T. C_R reaches zero at time t' which satisfies

$$\left(\tilde{C} + \frac{\rho T'^2}{2\Theta}\right) e^{-t'/T'} = \frac{\rho T'^2}{2\Theta}. \tag{24}$$

The total discounted utility is given by

$$u = -\int_0^{t'} \frac{1}{\Theta} e^{-(\tilde{C}\theta/T' + \rho T'/2)e^{-t/T'} - \rho t} dt - \int_{t'}^{T} \frac{1}{\Theta} e^{-\rho t} dt. \tag{25}$$

I solved the first integral numerically for certain parameter specifications. Let us consider $T = 1000$, $\rho = 0.02$, $\Theta = 1$, and $\tilde{C} = 10000$. For $T' = 40$, t' equals 257.6 and $u = -0.60$. For $T' = 20$, t' is 156.5 and $u = -3.81$. For $T' = 10$, t' is 92.1 and $u = -11.66$. In comparison, the utility in the nonmyopic case is approximately $-2\ 10^{-6}$. Thus utility is sensitive to myopia in relative terms. If $T' = 40$, then utility is -2.29 for $\rho = 0.015$ and -10.06 for $\rho = 0.01$. Thus utility is also sensitive to ρ in this situation. In all these situations, the first and the second integral of the last equation are approximately of the same order.

4 Conclusion

The problem of limited natural resources is a big problem of the real world. The present paper tries to model this issue in a dynamic framework in which the total life-time amount of consumption is fixed. The problem is examined separately for logarithmic and exponential utility, and separately for nonmyopic and myopic preferences. In all these cases, the model can be solved analytically by the technique of the principle of variations. In all situations, consumption is decreasing over time. The total discounted utility may be increasing in the rate of time preference. The total discounted utility is lower for myopic than for nonmyopic preferences. The sensitivity of utility to the degree of myopia is in relative terms higher for exponential than for logarithmic utility. Future research could focus on plausible extensions of the present framework (e.g., by introducing production and investment) and could better answer the fundamental question of whether myopia really matters for the welfare of society.

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