A Normative Justification of Roefie Hueting's Sustainable National Income

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Draft, May 2005

Abstract: The Dutch economist Roefie Hueting has published since 1969 a long record of books and articles about the Sustainable National Income (SNI). He was one of the first economists who developed the idea of a SNI. The SNI is the present national income minus the abatement costs, which are necessary to preserve the status quo of the environment. Hueting defines the term environmental "sustainability" as strong sustainability, in the sense that *vital* environmental functions must be retained forever.

In this paper, we want to show that his claim for strong environmental sustainability is justifiable from a normative theoretical point of view. To do that we develop a simple endogenous over-lapping generations (OLG) growth model, which is based on a modified Harrod-Domar model. In this model, it is taken into account, that the environment plays an important role for economic growth. In the model it will be shown that a country, which ignores Hueting's claim for strong sustainability, will end up in a disaster, especially negative growth rates, rising unemployment and a never-ending depression. Additionally, we show that it is better to protect the environment today than tomorrow, because the relative costs to protect the environment are much lower today than in the future. Of course, these results imply that for e.g. the Kyoto-protocol is not efficient from an economic ecological point of view. In addition, the results imply that we must rethink radically about our way of life, if we take into account for e.g. that around 50% of the Dutch national income is not produced in a sustainable way.

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1. Introduction

In 1974 the Dutch economist Roefie Hueting published his doctoral dissertation on sustainable national income (SNI). This concept of environmental sustainability is one of the first ones and it is very well elaborated. Additionally, the SNI concept was used by Dutch econometricians, who calculated the differences between the actual NNI (National Net Income) of the Netherlands and the SNI of Hueting (1974, 1980). So we have some empirical data. The aim of this paper is written to give a normative justification for Hueting's claims.

However, before we start with the analysis, we explain the ideas of Hueting. Especially we look at the most relevant assumptions of Hueting and how he wants to justify these assumptions.

We will see that Hueting uses some critical assumptions, which should be discussed. Thereafter we introduce an endogenous growth model to show what are the consequences if a SNI would be introduced into economic policy. We want to proof if there exists an economic justification for the SNI. Especially, we want to proof that Hueting's claims fulfills the conventional efficiency criteria.

In the first part, we illustrate the ideas of Hueting and in the second part, we discuss his assumptions. The following part is based on economic theory. At the end, we conclude the results.

2. The Concept of a Sustainable National Income[1]

The Dutch economist Roefie Hueting has been writing on economics and the environment alongside the standard national income since at least 1967. In 1974, he published his thesis *"New Scarcity and Economic Growth"*.[2] In the view

* I thank Roefie Hueting, Bart de Boer, Carlie Geerdink and Bert Steenge for insightful comments and suggestions, all remaining errors are mine.

[1] Especially, I thank Roefie Hueting for proof-reading of this section. Nevertheless, the author is responsible for all remaining mistakes.

[2] Unfortunately, an English translation of Hueting's book was published only, not until 1980.

of Hueting, the System of National Accounts (SNA) should be extended with respect to environmental losses. This should be done because otherwise some important welfare losses of an economy are ignored.[3] This is the main thesis of his whole work.[4] Especially, he calls for an introduction of a practical concept of sustainability into the national accounting system. He was one of the first economists who developed the idea of Green National Income.

Hueting's contributions concern the relationship of the indicators for the Net National Income (NNI) and the Sustainable National Income (SNI). It is important to see that Hueting's work is founded theoretically, and applied to economic statistics. His objective is to provide adequate information to the users of statistical data about the state of the natural environment. These data are generally used in a future-oriented setting, but their value lies in their statistical quality. This section is mainly based on the work of Hueting & de Boer 2001, Hueting & Reijnders (1998), Hueting (1998)**, (**1970, 1974a, 1974b, 1980, 1992, 1995, 1996) and Hueting, Bosch & de Boer (1992, 1995).

Before we come to the details of Hueting's work, it is necessary to recall that national income accounting is founded in social welfare theory, which has been developed by Nobel Prize laureates in economics like Jan Tinbergen, Paul Samuelson, Simon Kuznets, John Hicks, James Meade and Richard Stone. The basic idea of Hueting is to compare the economic performance of a specific country in two different periods of time- the length of a time period is mostly one year- and to determine whether or not society has come closer to environmental sustainability, which is arguably an important factor influencing welfare. Since the Bergson-Samuelson social welfare function[5] (SWF) is not observable, we

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[3] The main base of human welfare is the volume of natural goods or better the environmental functions of natural goods, which are mostly ignored in the national accounts, because natural goods are the base of all production.

[4] He has published more than 75 articles, papers and books in English about this theme, and he is still on writing. Goodland (2001, p. 326-331) gives an overview about the work of Hueting until 2001.

[5] This welfare function goes back to Bergson (1938) and Samuelson (1956).

have to make do with factors that **are** measurable and that arguably influence welfare. One of these factors is arguably (net-) income per capita; observed market prices are used to deflate to real values. In this case, the statistical challenge thus is not income per se, but the development of income in relation to the available volume of environmental goods, the functions of our physical surroundings on which the production measured in national income is based [6]. Observed market prices were used because of the assumption of optimality of market economies. In most cases, it is an acceptable assumption that the current allocation is indeed optimal. It should be noted that this approach is misleading, if anybody suspects that the resources are not used optimally and income is not tangential to the SWF. Moreover, this was the case with the natural environment and natural resources in past.[7] National income is recorded at observed prices anyway, while separate indicators are provided on the state of the resources.

Hueting proposed the following solution to resolve these problems. In his opinion, it is a reasonable assumption, that we prefer the conservation of our natural environment absolutely to reach sustainability.[8] The foundation for his view about sustainability goes back to Mill's (1876) concept of "*steady state*" and "*stationary state*".[9] This implies that it is admissible to assume that the natural environment must be conserved by the living generation. This

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[6] The absolute value of real net income per head is relevant if someone wants to compare the economic performance of countries within the same period.

[7] This is caused by the fact that the natural environment has no market price and in most cases, the natural environment can be interpreted as a public good.

[8] There exist many different definitions in the literature on environmental sustainability (see Goodland (1995) for an overview): e.g. weak sustainability, strong sustainability. Hueting defines sustainability as a situation in which vital environmental functions remain available, so that production cannot *collapse* as a result of the destruction of one or more environmental functions. In Hueting's view sustainability is in principle defined as scientifically objective. (See Hueting & Reijnders (1998), Reijnders (1996)).

[9] Steady state and stationary state means a state, which is sustainable forever. For details, see Stauvermann (1997).

consideration is based on the principle of the assumed preferences for intergenerational equity.[10]

The idea of Hueting is to calculate the costs for the conservation of the natural environment and to subtract these costs from the NNI. To establish an appropriate maximum environmental burden to meet these preferences, it is seen as a task for natural scientists to inform about physical standards.

Given his assumptions concerning preferences for sustainability, it follows that the value of environmental degradation is equal to the conservation costs.[11] Additionally, given that these costs are known, it is possible to calculate a SNI. It is the difference between the Net National Income (NNI) minus the aggregated costs to preserve the natural environment from degradation. Or in the words of Hueting & de Boer (2001, p. 19 and p.70):

"The SNI according to Hueting is the maximum net income which can be sustained on a geological time scale, with future technology progress assumed only in the development of substitutes for non-renewable resources, where such substitution is indispensable for sustaining environmental functions, in turn essential for sustaining income."

In so far Hueting's answer has been to hold on to the classical notion of Hicks (1948), and to try to find the counterfactual tangential point of the NNI. The difference of both incomes then is a measure or indicator for the distance between the current state of the economy and the sustainable economy. The gap between the NNI and SNI measures the part of production which is unsustainable. If the gap is increasing the growth of the economy is becoming more unsustainable. If it the gap decreases, the growth is becoming more sustainable.

Additionally, Hueting introduced his concept of 'blockages' to find a way in which statistics can deal with the situation that the social preferences of the citizens are unknown and that there exist no sufficient mechanism today to find

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[10] A formal representation is given in Barro (1974).

[11]The costs contain the costs of preserving the environment and the costs of removing existing environmental burden.

out the true social preferences.[12] The main problem is that preferences for future availability of environmental functions can only very partially be derived from expenditures on compensation measures for and restoration of losses of function and from (monetary) damages resulting from loss of function, because these losses have not yet occurred in the future. The idea is that sustainability can be defined objectively and could be estimated. The concept of 'blockages' implies that people would accept the standard of sustainability, even if they do not reveal this preference today because they are not able to do so (The individuals are 'blocked'.).[13] The resulting yardstick thus does not impose preferences, but provides information for the democratic process to be able to decide about actual adoption or not.

The assumptions of Hueting avoid the problem that we must have knowledge about the future. Otherwise, we will run into unsolvable problems.[14] However, before a SNI can be calculated some other problems must be resolved. The first is how should we account the environment, if it has different functions

[12] Arrow (1951) has proved that it is in general not possible to construct a social welfare function, which satisfies five plausible axioms. This is the message of the so-called "Arrow´ s impossibility theorem". See e.g. Stiglitz (1988).

[13] A possible reason is that the greatest part of the environment or the environmental functions are public goods. Then it is not possible to reveal the true preferences of the people, because there exists no mechanism to reveal the true preferences of the members of the economy. Apart from the fact that expenditures on compensation and financial damage can reveal preferences for environmental functions only very partially, there is the problem to reveal the true preferences because of the so-called prisoners dilemma. (See for an game-theoretic foundation, e.g. Rasmussen (1989) or Fudenberg & Tirole (1996) and the cited literature there.) Although everybody knows that the environmental basis of human life is in danger, it seems to be rational from the individualistic view not to behave in a way that does not damage the environment because this causes the individual a substantial disadvantage while the effect is negligible and it is doubtful that others will follow suit. In so far the individuals are blocked.

[14] E.g. the models of Weitzman (1976) and of Hartwick (1977), which was built on Solow (1974), are based on very strong assumptions: identical consumer preferences, certain future, no technical change, constant time preferences of the consumers and no distortionary taxes or subsidies. The results of these models break down, if we relax these assumptions.

for the economy. An example that was given by Hueting (1980, p. 95) is water. Water is a natural resource, without any doubt, but water has different functions. A distinction can be made between the following functions: water for drinking, water for cooling, water for flushing and transport, process water, water for agricultural purposes, water for recreation, water in the natural environment, water for construction and water as a dumping ground for waste.[15] Undoubtedly, different environmental functions of an environmental good compete with each other and therefore meet the definition of economic scarcity. Because of this, the different functions can be interpreted as economic goods.

The concept of an environmental function was also introduced by Hueting (1970). Briefly, environmental functions are defined as possible uses of humanity’s biophysical surroundings: water, air, soil, natural resources, plants, and animals. (Hueting & Reijnders (1998, p. 143)).[16] Then sustainability in the sense of Hueting can be defined as the use of environmental functions in a way that they remain available forever. If we know the cost function for conserving a function of an environmental good, we get the supply curve of the environmental function.

The following figure shall explain Hueting's ideas about the demand and supply side for an environmental function.

[15] It should be noted that the functions could be subdivided. For e.g. recreational water can be subdivided into water for swimming, fishing, boating, skating and waterside recreation.

[16] However, noise pollution per se plays no role in Hueting' s concept, because it does not influence the environment in the long run.

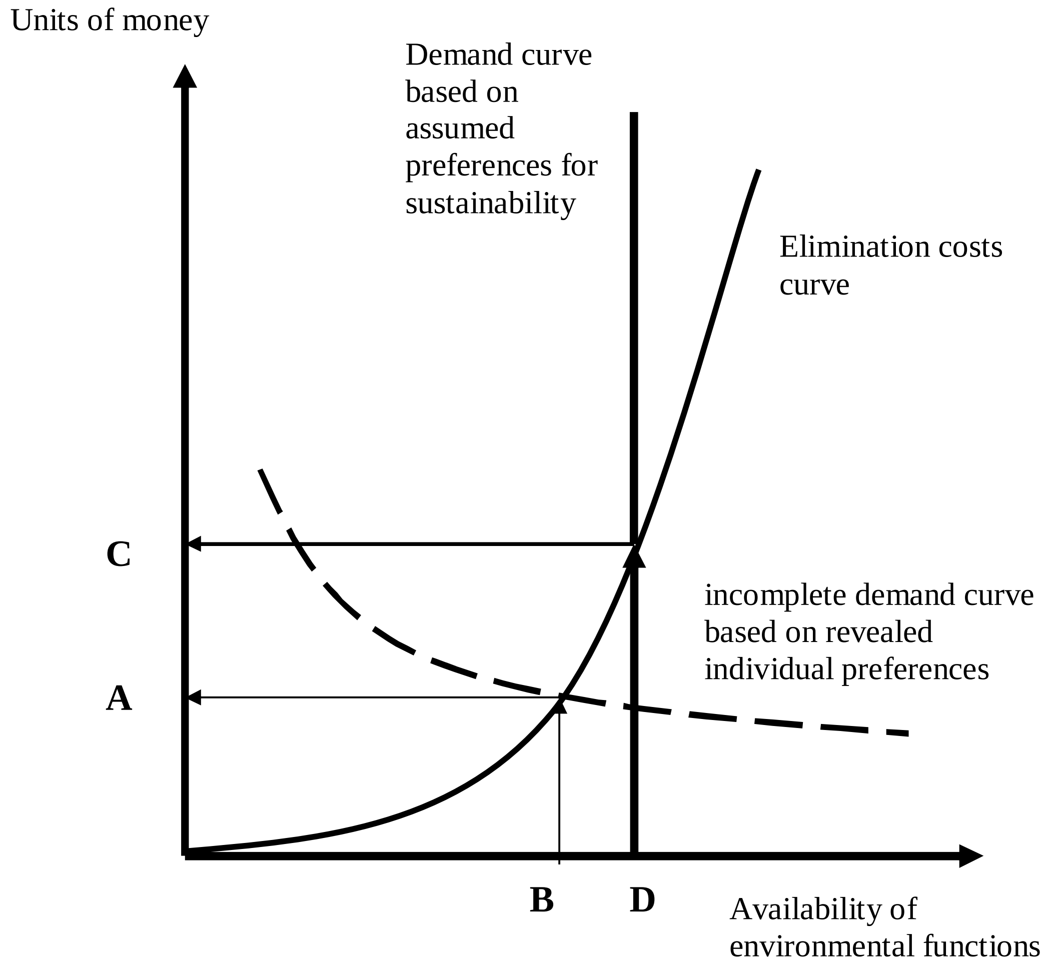

Figure 1[17]

In Figure 1 the point B represent the availability of environmental functions in the present. The point D represents the minimum of environmental functions to preserve the environment from degradation. The dashed line reflects the

[17] An example for the elimination costs curve: Think of specific species. Then it is obvious, that a critical level of numbers of individuals exist to guarantee the survival of this species. If the numbers of individuals fall short of this critical level, the species will be extinct in the near future. So it is possible to determine the corresponding point on the elimination cost curve, which guarantees the survival of the species.

incomplete demand curve revealed from expenditures on compensating loss of environmental function and from financial damage. The vertical line represents the demand curve derived from the assumed preferences for strong sustainability. The elimination costs curve can be interpreted as a supply curve of environmental functions. To realize sustainability the society must abstain from consuming BD physical units of environmental functions or expressed in money terms, the society must forego AC units of money.

Given that the elimination cost curves for all environmental goods and demand curves for strong sustainability are known, it is easy to calculate the value of the environmental burden. The elimination costs are inputs in an economic model that generates the SNI according to Hueting and also the prices of market goods and environmental functions in a environmentally sustainable situation.

The SNI of Hueting was grounded from the beginning on the system of national accounts as a basis for political decision making, and he accesses the SNI already as a partial welfare index, while other indices often call this system into question. Hueting tries to compare current NNI with his SNI, and he thus excludes problems like income distribution and issues like work at home. The SNI of Hueting is partly similar to alternative measures, but none of the latter ones has all properties as Hueting's SNI.

Overall, there remains a distinct difference between the different indicators. Let us summarize the main properties of the SNI of Hueting.

The idea of Hueting is based on the following principles:[18]

I. Hueting remains within the conventional methods of national accounting, especially the SNA. However, Hueting introduces a new figure of national income, the SNI.

II. Hueting's estimation of the SNI is based on four assumptions:

1. The concept of welfare is conventional. This means that, if there exists

[18] See Hueting & de Boer (2001, p 18).

a strong preference to conserve the natural environment, conservation measures will decrease the NNI and will increase welfare.

2. The concept of environmental functions, where each function must be interpreted as an economic good.

3. It is an assumption that there exist a majority of members of an economy for strong sustainability. Strong sustainability for itself is an objective and scientific concept.

4. To calculate the value of environmental functions, the supply and the demand curves must be known. In principle, it is possible to get data about the supply curve, which are determined by the elimination costs. The problem is the aggregate demand curve, because it exists no mechanism to reveal the true preferences of the individuals, because of blockages and because contingent valuation techniques cannot yield reliable data precisely for the most serious problems which occur on a global scale such as the greenhouse effect and the extinction of species. Therefore, assumptions about the preferences must be made like a preference for strong environmental sustainability.

5. All countries in the world accept simultaneously the measures necessary to arrive at an environmentally sustainable situation.

3 The Model

In this section, we want to show, that in general the SNI describes an optimal growth-path. The thesis is that the realization of a SNI is economically efficient under the assumption of strong preferences for sustainability. To show this we make use of a simple overlapping generations model and an endogenous growth model. The structure of the model is similar to the approaches of Smulders (1999) and Smulders & Gradus (1996).[19]

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[19] However there exist some fundamental differences: Firstly, both cited models use an infinitely living individual. This Solow-type model with respect to consumers can be interpreted as an OLG-model with altruism in the sense of Barro (1974). Secondly, he interprets the capital as knowledge. This difference between the models is not important (see Stauvermann (1997)).

3.1 The Consumers

We use an overlapping-generations model of the Diamond (1965) type, where we integrate the relative income hypothesis of Duesenberry (1949).[20] ***The idea of James Duesenberry is that "poverty is relative". It should be noted that Duesenberry's hypothesis apparently made economists uncomfortable because "it seemed more like sociology or psychology than economics." Robert Frank (Cornell University) has stated that Duesenberry's "theory rests on a more realistic model of human nature then others" and "has also been more successful in tracking actual spending." In principle Duesenberry stated that the well-being of humans does not depend on absolute income, but on the relative one. This idea is not new, also Thorstein Veblen and Karl Marx have argued in the same way. E.g. Karl Marx gave the following example: If you are living in a small wooden house and all your neighbors are living in tents, then you feel very good and to be rich; but if all your neighbors are living in palaces, then you feel bad and to be poor.***

That means that the utility of consumption depends not only on own consumption, but also on the average income or average consumption of the society. In every period, two generations are alive. The agents of each generation live for two periods. In the first period, they supply their labor force inelastically, earn a wage income and save a part of it. In the second period, they live from the fruits of their savings. A representative individual has to maximize her utility

(1) $\max_{c_t^1, c_{t+1}^2} U\left(\frac{c_t^1}{c_t}, \frac{c_{t+1}^2}{c_{t+1}}\right) = \ln\left(\frac{c_t^1}{c_t}\right) + p\ln\left(\frac{c_{t+1}^2}{c_{t+1}}\right)$, where the factor $p > 0$ represents the time preference,

[20] This idea goes back to Adam Smith and Karl Marx. But mostly is this approach ignored although the assumptions are obvious. However, there is long list of empirical literature which confirms the relative income hypothesis. See e.g. Easterlin (1974, 1995), Van Praag, Bernard & Kapeteyn (1973), Alpizar, Carlsson & Johansson-Stenman (2005), Blanchflower & Oswald (2004) or the special edition of Journal of Economic Behavior and Organization Vol 45 (2001).

(2) s.t. $c_t^1 + s_t \le w_t$ and $\frac{c_{t+1}^2}{R_{t+1}} \le s_t$.

The utility function U is continuous, twice differentiable, quasi-concave and homothetic. The population grows with the constant rate ***n***. The variable R_{t+1} is the interest factor, w_t is the wage rate and c_t^i is the consumption of an individual born in period t and living in her i-th period of life, the variable c_t represents the average consumption of the young in period t and c_{t+1} represents the average consumption of the old generation in period t+1. From maximizing (1), we get the following saving function:

$$(3) \qquad s_t = s\left(\frac{w_t}{\overline{w}_t}, R_{t+1}\right) = \arg\max_{0 \le s \le w_t} U\left(\frac{w_t - s_t}{c_t}, \frac{R_{t+1} s_t}{c_{t+1}}\right).$$

We transform equation (3) into the following way

$$(4) \qquad s\left(\frac{w_t}{\overline{w}_t}, R_{t+1}\right) = \frac{p}{1+p} w_t = s w_t ,$$

where $0 < \frac{p}{1+p} < 1$. That means that the elasticity of savings with respect to the interest rate is zero.

It should be noted that the consumption pattern determined by the utility function (1) is the same as we would use a conventional log-linear utility function.[21]

3.2 The Production

Here we look at the AK production technology to realize endogenous growth. This approach can be deduced with the help of the ideas of Romer (1986) and Rebelo (1991), which are based on neoclassical assumptions or it can be deduced from the post-Keynesian model of Hussein & Thirlwall (2000). While Romer (1986) used a Neoclassical production function, Hussein & Thirlwall (2000) used a Leontief production function.

[21] A general proof for this implication is given in Hollander (2001).

However, we must introduce the variable environmental resources into the model. This environmental resources can be interpreted as forests, lakes, air or something like this. This variable fulfills the characters of a public good, which is necessary for the production of material goods. It seems to be obvious, that the environmental resources or environmental functions of these resources are restrictions for the production of material goods. In principle the quantity of available environmental functions determine an upper limit of production in every period of time. This can be formalized in the following way:

$$(5) \qquad Y_t = A\min[K_t, L_t, E_t],$$

where A is a positive constant, K_t represents the capital stock, L_t the labor force and E_t represents the quantity of an environmental function.[22] To make the analysis as easy as possible, we assume without loss of generality that $L_t > K_t$. Given this assumption, we get the following from (5):

$$(6) \qquad Y_t = \begin{cases} AK_t, \text{if } K_t < E_t \\ AE_t, \text{if } K_t \geq E_t \end{cases}.$$

The distribution of income is assumed to depend only on institutional rules (e.g. labor laws, jurisdiction etc.).[23] So we fine $1-\alpha$ as fixed labor share and α as the fixed capital share. The aggregate labor income W_t is then

$$(7) \qquad W_t = \begin{cases} (1-\alpha)AK_t, \text{if } K_t < E_t \\ (1-\alpha)AE_t, \text{if } K_t \geq E_t \end{cases}$$

and the interest factor R_t, where we assume that the depreciation rate of capital is 100% in a period[24]:

[22] It is easy to see that this production function could be extended to more than one environmental function.
[23] For a detailed analysis of this income distribution see Stauvermann (2005).

(8) $$R_t = \begin{cases} \alpha A, \text{ if } K_t < E_t \\ \alpha \frac{AE_t}{K_t}, \text{ if } K_t \geq E_t \end{cases}.$$

Now we know all factor prices. Now let us look at the development of the environmental function. To make the analysis as easy as possible we assume the following:

(9) $$E_t = E_{t-1} - bY_{t-1}^{\beta} + dG_{t-1}^{\gamma},$$

where b and d are positive constants and $\beta > \gamma > 0$ and $0 < \gamma < 1$. The variable G_{t-1} are the expenditures to protect the environmental function. The interpretation of function (9) is the following. The quantity of an environmental function in period t depends on the quantity of this environmental function in period t-1 minus the environmental damages bY_{t-1}^{β} caused by the production in period t-1 plus the efforts dG_{t-1}^{γ} to restore the environmental function.

3.3 The Dynamics

I think it is useful to assume that we start with dynamic analysis, where $E_t > K_t$. That means that the capital accumulation determines the growth rates of the economy. The capital stock in period t+1 is then:

(10) $$K_{t+1} = sW_t = s(1-\alpha)AK_t.$$

The resulting growth factor is given by:

(11) $$1 + g_t = s(1-\alpha)A.$$

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[24] ***The definition of the interest factor or profit factor R_t is:***
$R_t = 1 + r_t - d_t$, where the depreciation rate $d_t = 1$ or (100%), that means $R_t = r_t$.

If this term is bigger than one, the economy will grow as long as $E_t > K_t$ will hold in the future. A positive per-capita growth rate will be realized if $s(1-\alpha)A > 1+n$, where n is the growth rate of the labor force.[25]

Now the question will be what happens with the environmental function? The value of it without any effort to restore the environment is given by

(12) $$E_{t+1} = E_t - b(AK_t)^{\beta}.$$

Consequently, the growth factor of the environmental function is given by:

(13) $$\frac{E_{t+1}}{E_t} = 1 - \frac{b(AK_t)^{\beta}}{E_t} < 1.$$

We see that the growth factor is always smaller than one, what means that there is a permanently decrease of the environmental function. The rate of decrease of the environmental function will increase if the production increases. That means after some periods of time the quantity of environmental function is lower than the physical capital stock. This will have strong consequences for the economic growth, because now the production is given by:

(14) $$Y_t = AE_t.$$

Consequently the production in t+1 is given by

(15) $$Y_{t+1} = A\left[E_t - b(AE_t)^{\beta}\right]$$

From (14) and (15) we calculate the growth factor of the economy:

[25] If this condition holds, the assumption $L_t > K_t$ always hold.

(16) $$1+g_t = \frac{A\left[E_t - b(AE_t)^{\beta}\right]}{AE_t} = 1 - b(AE_t)^{\beta-1} < 1$$

This factor is obviously smaller than one and so the growth rate of the economy is negative. At the same time the quantity of the environmental function is decreasing:

(18) $$\frac{E_{t+1}}{E_t} = 1 - bA^{\beta}(E_t)^{\beta-1} < 1.$$

So we come to the result, if an economy does not do anything for its environment the economy will vanish in the long-run.

4 A Sustainable Growth Path

Now we know that an economy must behave sustainable. That means that some amount of money must be invested to preserve the environment. The second reason for an introduction of an environmental tax is that there is a negative externality stemming from the production of material goods. Let us assume that the starting point is the same as in the latter section. But now the government introduces an environmental tax to finance the protection of the environment. This means that the status of the environment must remain constant over time. $E_t = E_{t+1}$, if $bY_t^{\beta} = dG_t^{\gamma}$. Solving for G_t gives:

(19) $$G_t^S = \left(\frac{b}{d}\right)^{\frac{1}{\gamma}} Y_t^{\frac{\beta}{\gamma}} = \left(\frac{b}{d}\right)^{\frac{1}{\gamma}} (AK_t)^{\frac{\beta}{\gamma}}.$$

We see that the costs to preserve the environment could be higher than the value of production. I hope that is not the case in reality. So we assume optimistically, that the relation *b/d* is small enough to finance the preservation costs. That means that $G_t^S < AK_t$. If the contrary holds, it will be never possible to save the natural environment. This is caused by the fact that the growth factor of G^S is given by $\frac{G_{t+1}^S}{G_t^S} = (1+g_t)^{\frac{b}{g}} > 1 + g_t = \frac{Y_{t+1}}{Y_t}$. We get the result: if it is not possible to preserve the environment in period t it is also impossible to preserve the environment in period t+1, although the quantity of environmental functions is decreased.

However, let us now look at the following scenario: It is possible to preserve the environment in period t. Then the production in period t+1 will be:

$$(20) \qquad Y_{t+1} = s(1-a)A\left(AK_t - G_t^S\right) = s(1-a)A\left(1-\left(\frac{b}{d}\right)^{\frac{1}{g}}\left(AK_t\right)^{\frac{b}{g}-1}\right)AK_t\,.$$

In our model the difference between production and preservation costs can be interpreted as a SNI, because the status of the environment remains unchanged. The resulting growth factor of production is then given by

$$(21) \qquad \frac{Y_{t+1}}{Y_t} = s(1-a)A\left(1-\left(\frac{b}{d}\right)^{\frac{1}{g}}\left(AK_t\right)^{\frac{b}{g}-1}\right).$$

That means that the growth rate of a sustainable economy is lower than the growth rate of a unsustainable economy. This result is obvious. Additionally, the growth factor of the economy could be positive. But from period to period it will become more costly to preserve the environment so that after a number of periods a steady-state will be reached. The steady-state capital stock is given by

$$(22) \qquad K^* = \frac{\left(\frac{s(1-a)A-1}{s(1-a)A}\right)^{\frac{g}{b-g}}\left(\frac{b}{d}\right)^{\frac{b}{g-b}}}{A}.$$

That means only if this steady-state will be realized, the economy will be sustainable. However, someone would ask, what will happen if we would make use of the concept of weak sustainability? The answer is obvious, in qualitatively the same will happen as we would do nothing for the environment. Only the time horizon will be longer. In so far the only possible long-run solution for an economy is to follow a strong sustainable path.

5. Welfare analysis

Let us now come to the welfare effects. We will show that the utility of anyone will be harmed, if the costs to protect the environment G_t^S are financed by a tax that does not influence the distribution of income. Let us prove that.

Given the utility function (1) and the budget constraint, we can reformulate the utility function in the following way:

$$(23)\quad U\left(\frac{c_t^1}{c_t},\frac{c_{t+1}^2}{c_{t+1}}\right)=\ln\left(\frac{c_t^1}{c_t}\right)+p\ln\left(\frac{c_{t+1}^2}{c_{t+1}}\right)=\ln\left(\frac{\frac{w_t}{1+p}}{\frac{\overline{w}_t}{1+p}}\right)+p\ln\left(\frac{\frac{pw_tR_{t+1}}{1+p}}{\frac{p\overline{w}_tR_{t+1}}{1+p}}\right)$$

$$\Leftrightarrow U\left(\frac{c_t^1}{c_t},\frac{c_{t+1}^2}{c_{t+1}}\right)=\ln\left(\frac{w_t}{\overline{w}_t}\right)+p\ln\left(\frac{w_t}{\overline{w}_t}\right).$$

We see that the utility level of an individual depends only on the individual wage rate in relation to the average wage rate of this generation. If we now introduce a wage tax rate t, where the tax revenue must equal the optimal environmental protection costs, we get the following welfare effect:

$$(24)\quad U\left(\frac{c_t^1}{c_t},\frac{c_{t+1}^2}{c_{t+1}},t_t\right)=\ln\left(\frac{(1-t_t)w_t}{(1-t_t)\overline{w}_t}\right)+p\ln\left(\frac{(1-t_t)w_t}{(1-t_t)\overline{w}_t}\right)=U\left(\frac{c_t^1}{c_t},\frac{c_{t+1}^2}{c_{t+1}}\right).$$

That means that the utility of no individual is harmed, but because of the effect that the environment will be unchanged forever, some unborn generations will be better off. In so far the introduction SNI does not harm any generation or any individual. The introduction is a real Pareto-improvement.

6 Conclusion

With the help of an endogenous growth model, in which consumption of environmental goods (pollution) is a by-product of economic activity and in which the environment goods can be restored by spending a part of the aggregate output, we have shown two important things with respect to environmental policy. The model confronts two opposing sides on the interaction between economic growth and the stock of environmental goods. On the one side growth causes the consumption of environmental goods and on the other side growth generates resources for protecting or restoration of environmental goods.

At first we have shown that introduction of environmental care is Pareto-efficient, if all natural resources will be destroyed after some periods without environmental care. This result can be based only on the fact that the producers did not into account the negative externalities stemming from material production. ***The reason is that they have not to pay for the use of natural resources, even if it is necessary to produce something, because natureis mostly a public good.***

And there is no reason to argue that the living generations should have the right to destroy the basis of living of the following generations..

However, we can conclude that a Pareto-efficient policy is to restore environmental functions, where we have identical to Hueting not taken into account the utility of the environment. ***That means, that we have not taken into account the utility of nature for humans, e.g. that the environment for itself is a consumption good (to breath unpolluted air, to swim in clean water, to enjoy the nature etc.).***

Tinbergen & Hueting (1991) calculate a reduction of the disposal national income of around one half to reach strong sustainability.[26] However, Hueting's SNI is a practicable approach to get an insight into the costs to reach strong sustainability. And with the help of our model, it becomes clear that Hueting's assumptions are very similar to ones which were used in the growth model to show that the introduction SNI as a goal is a Pareto-improvement.

[26] Verbruggen, Dellink, Gerlagh, Hofkes & Jansen (2001) came to similar results

References

Alpizar, F. Carlsson, F. & Johansson-Stenman, O. 2005: How Much Do We Care about Absolute versus Relative Income and Consumption, Journal of Economic Behavior and Organization 56, 405-421

Barro, R. J., 1974: Are Government Bonds Net Wealth?, Journal of Political Economy 81, 1095-1117

Bergson, A. 1938: A Reformulation of Certain Aspects of Welfare Economics, Quarterly Journal of Economics 52, 310-334

Blanchflower, D.G. & Oswald A.J. 2004: Well-Being over time in Brtain and the USA, Journal of Public Economics 88, 1359-1386

De Boer, B. 2002: Economische Structurenen milieugebruik; basisrapport van het project Duurzaam Nationaal Inkomen, concept, Statistics Netherlands, Voorburg

Dellink, R., Gerlagh, R. & Hofkes, M.W. 2001: Calibration of an Applied General Equilibrium Model for the Netherlands 1990, IVM Report W-01/17, Institute for Environmental Studies, Amsterdam, The Netherlands

Diamond, P. 1965: National Debt in a Neoclassical Growth Model, American Economic Review 55, 1126-1150

Duesenberry, J. S 1949: Income, Saving and the Theory of Consumer Behavior, Harvard University Press

Easterlin, R.A. 1974: Does Economic Growth enhance The Human Lot? Some Empirical Evidence, in: David, P.A. & Reder, M. (eds.): Nations and Households in Economic Growth: Essays in Honour of Moses Abramovitz, Stanford University Press, 89-125

Easterlin, R.A. 1995: Will Raising Incomes of All increase the Happiness of All?, Journal of Economic Behavior and Organization 27, 35-47

Fudenberg, D. & Tirole, J. 1996: Game Theory, 5th edition, MIT Press, Cambridge, MA

Gerlagh, R., Dellink R., Hofkes, M. & Verbruggen, H. 2001: Calibration of an Applied General Equilibrium Model for the Netherlands, IVM Report W-01/16, Institute for Environmental Studies, Amsterdam, The Netherlands

Gerlagh, R., Dellink R., Hofkes, M. & Verbruggen, H. 2002: A Measure of Sustainable National Income for the Netherlands, Ecological Economics 41, 157-174

Goodland, R. 2001: An Appreciation of Dr Roefie Hueting's Ecological Work, 315-332, in: Van Ierland, E., van der Straaten & Vollebergh H. (eds.): Economic Growth and Valuation of the Environment: A Debate, Edgar Elgar, London

Hartwick, J.M. 1977: Intergenerational Equity and the Investing of Rents from Exhaustible Resources, American Economic Review 67, 972-974

Hicks, J.R. 1948: The Valuation of the Social Income: A Comment of Professor Kuznets' Reflections, Economica 15, 163-72

Hofkes, M.W., Gerlagh, R., Lise, W. & Verbruggen, H. 2002: Is Economic Growth Sustainable? A Trend Analysis for the Netherlands, 1990-1995, Discussion paper IVM Institute for Environmental Studies, Vrije Universiteit Amsterdam

Hollander, H. 2001: On the Validity of Utility Statements: Standard vs. Duesenberry’s, Journal of Economic Behavior and Organization 45, 227-249

Hueting, R. & de Boer 2001a: Environmental Valuation and Sustainable National Income according to Hueting, 17-78 in: Van Ierland, E., van der Straaten & Vollebergh H. (eds.): Economic Growth and Valuation of the Environment: A Debate, Edgar Elgar, London

Hueting, R. & de Boer 2001b: The Parable of the Carpenter, International Journal of Environment and Pollution 15, 42-50

Hueting, R. & L. Reijnders 1998: Sustainability is an objective concept, Ecologic Economics 27, 139-147

Hueting, R. 1970: Functions of Nature: Should Nature be quantified?, Economisch-Statistische Berichten, 21 January (written in Dutch)

Hueting, R. 1974b: A Statistical System for Estimating the Deterioration of the Human Environment, in: Pratt, J.W. (Ed.): Statistical and Mathematical Aspects of Pollution Problems, Symposium of the International Association of Statistics and Physical Sciences (IASPS), Harvard University, Aug. 10-20, 1971, Marcel Dekker, New York

Hueting, R. 1980: New Scarcity and Economic Growth: More Welfare through Less Production?, Amsterdam, North Holland Publishing Company. (Translation of Hueting (1974))

Hueting, R. 1992: The Economic Functions of the Environment, in: Ekins, P. & Max-Neef, M. (eds.): Real-Life Economics, Routledge, London

Hueting, R. 1995: Estimating Sustainable National Income, in: van Dieren, W. (ed.): Taking the Nature into Account-Towards a Sustainable National Income, Springer Verlag, Heidelberg

Hueting, R. 1996: Three Persistent Myths in the Environment Debate, Ecological Economics 18, 81-88

Hueting, R. 2001: Rejoinders to Symposium Authors, 333-378 in: Van Ierland, E., van der Straaten & Vollebergh H. (eds.): Economic Growth and Valuation of the Environment: A Debate, Edgar Elgar, London

Hueting, R., Bosch, P. & de Boer, B. 1992: Methodology for the Calculation of Sustainable National Income, Statistical Essays M44, Netherlands Central Statistical Office, Voorburg

Hueting, R., Bosch, P. & de Boer, B. 1995: The Calculation of Sustainable National Income, Occasional Papers and Reprints, IDPAD OP& R 1995-2, Indo-Dutch Programs on Alternatives in Development IDPAD, New Delhi, The Hague

Hussein, K. & Thirlwall, A.P. 2000: The AK Model of 'New' Growth Theory is the Harrod-Domar Equation: Investment and Growth Revisited, Journal of Post Keynesian Econommics 22, 427-435

Rasmussen, E. 1989: Games and Information: An Introduction to Game Theory, Basil Blackwell, Cambridge, MA

Rebelo, S. 1991: Long Run Policy Analysis and Long Run Growth, Journal of Political Economy, 99, 500-521

Romer, P.M. 1986: Increasing Returns and Long-run Growth, Journal of Political Economy 94, S. 1002-37

Samuelson, P.A. 1956: Social Indifference Curves, Quarterly Journal of Economics 70, 16-17

Smulders, S. & Gradus, R. 1996: Pollution Abatement and Long-term Growth, European Journal of Political Economy 12, 505-532

Smulders, S. 1999: Endogenous Growth Theory and the Environment, in: J.C.J.M. van den Bergh (ed.): Handbook of Environmental and Resource Economics, Northampton, MA, Edgar Elgar ,610-621

Solow, R. M. 1974: Intergenerational Equity and Exhaustible Resources, Review of Economic Studies 41, 29-45

Stauvermann, P. 1997: Endogenous Growth in OLG-Models, Wiesbaden

Stiglitz, J.E. 1988: The Economics of the Public Sector, 2nd edition, New York, W. Norton & Co

Van Praag, B. Bernard, M.S. & Kapteyn, A. 1973: Further Evidence on the Individual Welfare Function of Income: An Empirical Investigation in the Netherlands, European Economic Review 4, 33-62

Verbruggen, H., Dellink, R.B., Gerlagh, R., Hofkes, M.W. & Jansen, H.M.A. 2001: Alternative Calculations of a Sustainable National Income for the Netherlands According to Hueting, 275-313, in: Van Ierland, E., van der Straaten & Vollebergh H. (eds.): Economic Growth and Valuation of the Environment: A Debate, Edgar Elgar, London

Weitzman, M.L. 1976: On the Welfare Significance of National Product in a Dynamic Economy, Quarterly Journal of Economics 90, 156-162