Intergenerational Ethics under Resource Constraints*

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1. Introduction

How should we treat future generations? From a normative point of view, what are the present generation's obligations towards the future? What ethical criterion for intergenerational justice should be adopted if one seeks to treat different generations in an impartial manner?

These questions can be approached and answered in at least two ways:

1. Through an axiomatic analysis one can investigate on what fundamental ethical conditions various criteria for intergenerational justice are based, and then proceed to evaluate the normative appeal of these conditions.
2. By considering different kinds of technological environments (e.g., growth models without or with the restrictions imposed by natural resource constraints), one can explore the consequences of various criteria for intergenerational justice, and compare the properties of the intergenerational utility streams that are generated.

It is consistent with Rawls' (1971) *reflective equilibrium* to do both: criteria for intergenerational justice should not only be judged by the ethical conditions on which they build, but also by their consequences in specific environments. In particular, we may question the appropriateness of a criterion for intergenerational justice if it produces unacceptable outcomes in relevant technological

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environments. This view has been supported by many scholars, including Atkinson, who writes

> … the relation between economics and ethical principles is not linear but rather iterative. Examination of the implications of moral principles in particular models may lead to their revision. By applying ethical criteria to concrete economic models, we learn about their consequences, and this may change our views about their attractiveness (Atkinson, 2001, p. 206).

and Dasgupta and Heal, who conclude "… it is legitimate to revise or criticize ethical norms in the light of their implications" (Dasgupta and Heal, 1979, p. 311).

When evaluating long-term policies, economists usually suggest to maximize the sum of discounted utilities. On the one hand, such *discounted utilitarianism* has been given a solid axiomatic foundation by Koopmans (1960). On the other hand, this criterion has questionable ethical implications when applied to economic models with resource constraints, as demonstrated by Dasgupta and Heal (1974) in the so-called Dasgupta-Heal-Solow (DHS) model of capital accumulation and resource depletion (Dasgupta and Heal, 1974, 1979; Solow, 1974). Hence, the DHS model points to the importance of testing criteria by their consequences in specific technological environments.

This paper illustrates the concept of reflective equilibrium by first (in Section 2) considering the consequences of a class of utilitarian criteria (with and without discounting) in the DHS model (with and without resource constraints). Then (in Section 3) various ethical conditions for intergenerational preferences are presented, including a set similar to the one that Koopmans (1960) uses to axiomatize discounted utilitarianism. This section brings forward a central theme of the axiomatic literature on intergenerational justice, namely that there is a basic conflict between conditions that ensure efficiency on the one hand, and conditions that ensure equity, on the other hand. In particular, discounted utilitarianism, while leading to Pareto-efficient optimal streams, does not satisfy conditions that ensure equity in the sense of equal and impartial treatment of different generations.

The conflict between efficiency and equity arises when one insists on intergenerational preferences that can be represented by a social welfare function (cf. Basu and Mitra, 2003a), they are not incompatible by themselves. Building on Asheim, Buchholz and Tungodden (2001), I indicate in Section 4 how conditions of efficiency and equity can be used to justify the notion of *sustainable development*. Moreover, I present a guide to some recent contributions, which explore different ways out of the ethical dilemma posed by the impossibility of combining conditions ensuring both efficiency and equity with a social welfare function that represents the intergenerational preferences. Some concluding remarks are offered in Section 5.

2. The Ethical Significance of Resource Constraints

Consider the class of utilitarian criteria:

$$\max \int_0^{\infty} u(C(t))e^{-\rho t} dt,$$

where u is a utility function that specifies the well-being derived from non-negative consumption C, and $\rho \geq 0$ is the utility discount *rate*. By letting u have constant elasticity of marginal utility, i.e., $u(C) = C^{1-\eta}/(1-\eta)$, and assuming $\eta > 1$, the utility integral may converge, even if the discount rate ρ equals zero (this corresponds to how Ramsey, 1928, applies classical utilitarianism to infinite utility streams). We may interpret η as a parameter of inequality aversion.

Consider testing criteria in this class in the DHS model of capital accumulation and resource depletion:

$$Q = K^{\alpha} R^{\beta} = C + I,$$

where Q denotes non-negative production, K non-negative capital, and R non-negative resource input, and where $I := \dot{K}$ and

$$\alpha \geq \beta > 0, \alpha + \beta < 1.$$

The initial resource stock S is finite, implying that the integral of resource inputs is *constrained* to be finite:

$$\int_0^{\infty} R dt \leq S.$$

The DHS model, in the version presented above, is pessimistic by not allowing for technological progress. It is also pessimistic by not including *renewable* natural resources, only extraction of a *nonrenewable* resource is combined with capital to produce output. On the other hand, the model is optimistic with respect to the possibilities for substitution between capital and resource when the capital stock increases and resource input diminishes.[1] In the version presented above, it is also optimistic by not assuming that capital depreciates. I do not claim that this model describes accurately available production possibilities in the real world. As the subsequent analysis will show, however, it is well-suited to illustrate how a small variation in the parameters of the model may lead to very different consequences when combined with criteria for intergenerational justice.

In order to evaluate the ethical significance of resource constraints, one can now consider two different technological environments,

– the DHS model *without* resource constraints: $\beta = 0$,
– the DHS model *with* resource constraints: $\beta > 0$,

and for each of these, apply two utilitarian criteria for the evaluation of intergenerational utility streams,

– classical utilitarianism, entailing *equal* treatment of generations: $\rho = 0$,
– discounted utilitarianism, entailing *unequal* treatment of generations: $\rho > 0$.

This gives four cases in which utilitarian criteria can be tested in the DHS model, as illustrated in Table 1.

Table 1: Testing Utilitarian Criteria in the DHS Model

	Without resource constraints	With resource constraints
Classical utilitarianism	$\max \int_0^\infty \frac{1}{1-\eta} C^{1-\eta} dt$ s.t. $C = K^\alpha - \dot{K}$	$\max \int_0^\infty \frac{1}{1-\eta} C^{1-\eta} dt$ s.t. $C = K^\alpha R^\beta - \dot{K}$
Discounted utilitarianism	$\max \int_0^\infty \frac{1}{1-\eta} C^{1-\eta} e^{-\rho t} dt$ s.t. $C = K^\alpha - \dot{K}$	$\max \int_0^\infty \frac{1}{1-\eta} C^{1-\eta} e^{-\rho t} dt$ s.t. $C = K^\alpha R^\beta - \dot{K}$

1 If the elasticity of input substitution is below unity, then positive and non-decreasing consumption is not feasible with resource constraints. If the elasticity is above unity, then resource inputs are not essential. Hence, the Cobb-Douglas case – with unit elasticity of input substitution – is interesting, as it makes the resource essential, without ruling out sustainable development.

2.1 Classical Utilitarianism without Resource Constraints

The solution to the problem

$$\max \int_0^\infty \tfrac{1}{1-\eta} C^{1-\eta} dt,$$

subject to $C = K^\alpha - \dot{K}$, is given by:

$$\dot{K} = sK^\alpha \text{ and } C = (1-s)K^\alpha,$$

where s is a constant savings rate satisfying $s = 1/\eta < \alpha$. If $1/\alpha < \eta < \infty$, then a positive and constant fraction $s = 1/\eta$ of output is invested, while the remaining part is consumed. In this case, consumption grows beyond all bonds since, with a positive and constant savings rate, capital and output grow beyond all bonds. One may argue that classical utilitarianism thus leads to unacceptable inequalities in this model. If, one the other hand, $\eta = \infty$, then this limit of classical utilitarianism corresponds to the (Rawlsian) maximin criterion, entailing that the savings rate is zero. This leads to constant consumption. If the economy is poor to begin with, in the sense of having a small initial capital stock, then the maximin criterion perpetuates poverty. In either case, classical utilitarian (including the limiting case of maximin) can be criticized, for leading to unacceptable inequalities or for perpetuating poverty.

2.2 Discounted Utilitarianism without Resource Constraints

The solution to the problem

$$\max \int_0^\infty \tfrac{1}{1-\eta} C^{1-\eta} e^{-\rho t} dt,$$

subject to $C = K^\alpha - \dot{K}$, satisfies that

$$K \to \left(\frac{\alpha}{\rho}\right)^{\frac{1}{1-\alpha}} \text{ and } C \to \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}}$$

as $t \to \infty$. This means that an ethically appealing consumption stream that avoids unacceptable inequalities and does not perpetuate poverty can be implemented as an optimal stream by choosing ρ and η appropriately. In particular, with moderate discounting so that consumption is an increasing function of time, the discount rate ρ determines the upper bound on consumption, while the parameter of inequality aversion η determines the pace at which consumption converges to this upper bound. Hence, without resource constraints one may claim that discounted utilitarianism "works better" than classical undiscounted utilitarianism. If this technological environment corresponds to the mental model that most economists have, then it may also serve to explain their endorsement of discounted utilitarianism.

2.3 Classical Utilitarianism with Resource Constraints

The solution to the problem

$$\max \int_0^\infty \tfrac{1}{1-\eta} C^{1-\eta} dt,$$

subject to $C = K^\alpha R^\beta - \dot{K}$ and $\int_0^\infty R dt \leq S$, is given by:

$$\dot{K} = sK^\alpha R^\beta \text{ and } C = (1-s)K^\alpha R^\beta,$$

where s is a constant savings rate satisfying $s = \beta + (1-\beta)/\eta < \alpha$. If

$$(1-\beta)/(\alpha-\beta) < \eta < \infty,$$

then a positive and constant fraction $s = \beta + (1-\beta)/\eta$ of output is invested, while the remaining part is consumed. In this case, consumption grows beyond all bonds and one may argue that classical utilitarianism also with resource constraints leads to unacceptable inequalities. One the other hand, $\eta = \infty$, corresponding to the (Rawlsian) maximin criterion, entails that the savings rate compensates only for resource extraction. By in this way reinvesting resource rents (cf. Hartwick's rule; Hartwick, 1977), such savings behavior leads to constant consumption. If the economy is poor to begin with, in the sense of having a small initial capital stock, then the maximin criterion perpetuate poverty, as pointed out by Solow (1974) in the context of this model. In either case, the conclusions are exactly the same as in the model without resource constraints (except that the savings rate has to compensate for resource extraction): classical utilitarianism (including the limiting case of maximin) can be criticized, for leading to unacceptable inequalities or for perpetuating poverty.[2]

2.4 Discounted Utilitarianism with Resource Constraints

The solution to the problem

$$\max \int_0^\infty \tfrac{1}{1-\eta} C^{1-\eta} e^{-\rho t} dt,$$

subject to $C = K^\alpha R^\beta - \dot{K}$ and $\int_0^\infty R dt \leq S,$ entails that

$$K \to 0 \text{ and } C \to 0$$

as $t \to \infty,$ even though unbounded consumption growth is feasible. This conclusion holds independently of how small the positive utility discount rate is. The reason is the following: Along a stream where consumption is bounded away from zero, net capital productivity must approach zero as a result of capital accumulation and resource depletion. Such a stream cannot be optimal with a positive and constant discount rate. Hence, a positive utility discount rate ρ in the presence of resource constraints, by forcing consumption to (eventually) approach zero, leads to unacceptable inequalities and undermines the livelihood of future generations.

These four cases illustrate the importance of testing the consequences of ethical criteria in different environments. Even though discounted utilitarianism may compare favorably to classical utilitarianism in the model without resource constraints, by avoiding unacceptable inequalities and perpetual poverty, the conclusion is reversed when resource constraints are included. In the DHS model with resource constraints, discounted utilitarianism – for any positive utility discount rate – leads to consequences that undermine the livelihood of future generations and seems to be indefensible from an ethical point of view. Introducing positive discounting does not improve upon the utilitarian criterion in the case with resource constraints.

2 For a general analysis of classical utilitarianism and maximin in the DHS model, see Asheim, Buchholz, Hartwick, Mitra and Withagen (2005). This analysis considers also population growth.

3. Social Preferences over Intergenerational Utility Streams

The demonstration of the previous section shows both the importance and deficiency of testing criteria for intergenerational justice by their consequences in a class of technological environments. It is an important message that we should *not* extrapolate from an observation that a criterion leads appealing consequences in some environments, because this may not generalize to other environments. It is not sufficient since such testing does not give us an understanding of the underlying ethical principles on which various criteria for intergenerational justice build. This motivates an investigation of fundamental ethical conditions that can be imposed on social preferences over infinite utility streams.

KOOPMANS' (1960) axiomatic analysis of discounted utilitarianism is a seminal investigation of the fundamental ethical conditions on which a criteria for intergenerational justice builds. Following in his tradition, this section applies social choice theory to problems of intergenerational distribution, and considers the relationship between important ethical conditions, on the one hand, and well-known criteria for intergenerational justice, on the other hand.

While for growth theoretic analysis it is convenient to use continuous time, ethical conditions are most often formulated in a discrete time setting, with an infinite but countable number of generations. Let the instantaneous well-being of generation t be represented by utility u_t that can take on values in a set $Y \subseteq \mathbb{R}$, where $\mathbb{R}$ is the set of real numbers.[3] Let $X = Y^{\infty}$ be the set of all infinite utility streams, where $\infty = |\mathbb{N}|$ and $\mathbb{N}$ denotes the set of natural numbers. Denote by ${}_1\mathbf{u} = (u_1, u_2, \ldots)$ an element of X, and denote by ${}_1\mathbf{u}_T = (u_1, u_2, \ldots, u_T)$ and ${}_{T+1}\mathbf{u} = (u_{T+1}, u_{T+2}, \ldots)$ the T-head and T-tail of the utility stream ${}_1\mathbf{u}$ respectively.

Assume that there are social preferences R over the utility streams in X, where for any ${}_1\mathbf{u}, {}_1\mathbf{v} \in X$, ${}_1\mathbf{u} R {}_1\mathbf{v}$ entails that ${}_1\mathbf{u}$ is deemed socially at least as good as ${}_1\mathbf{v}$. Denote by I and P the symmetric and asymmetric parts of R; i.e., ${}_1\mathbf{u} I {}_1\mathbf{v}$ entails that ${}_1\mathbf{u}$ is deemed socially indifferent to ${}_1\mathbf{v}$ and ${}_1\mathbf{u} P {}_1\mathbf{v}$ entails that ${}_1\mathbf{u}$ is deemed socially preferable to ${}_1\mathbf{v}$.

3 A more general formulation is, as used by KOOPMANS (1960), to assume that the well-being of generation t depends on a n-dimensional consumption vector $\mathbf{C}_t$ that takes on values in a connected set. However, by representing the well-being of generation t by a scalar u_t one can focus on intergenerational issues. In doing so, I follow, e.g., DIAMOND (1965), CHICHILNISKY (1996), SUZUMURA and SHINOTSUKA (2003), ASHEIM and TUNGODDEN (2004b), and BOSSERT, SPRUMONT and SUZUMURA (2005).

There are different types of ethical conditions that can be imposed on intergenerational preferences. Firstly, *equity* conditions ensure, e.g., that different generations are treated in an equal and impartial manner. Secondly, *efficiency* conditions ensure that optimal utility streams are non-wasteful. Thirdly, *independence* conditions postulate that what happens in different periods are treated independently. Lastly, so-called *technical* conditions impose consistency and continuity requirements on the social preferences.

The most common equity condition is *Weak Anonymity* (**WA**). This condition ensures equal treatment of all generations by requiring that any finite permutation of utilities should not change the social evaluation of the stream. In the intergenerational context condition **WA** implies that it is not justifiable to discriminate against a generation only because it appears at a later stage on the time axis.

Condition WP *(Weak Anonymity)*: For any ${}_1\mathbf{u}, {}_1\mathbf{v} \in X$, ${}_1\mathbf{u} I_1 \mathbf{v}$ if ${}_1\mathbf{v}$ is derived from ${}_1\mathbf{u}$ through a finite permutation of utilities.

The most common efficiency condition is *Strong Pareto* (**SP**). This conditions ensures that the social preferences are sensitive to utility increases by any one generation by requiring that a utility stream is socially preferred to another if it at least one generation is better off and no generation is worse off.

Condition SP *(Strong Pareto)*: For any ${}_1\mathbf{u}, {}_1\mathbf{v} \in X$, ${}_1\mathbf{u} P_1 \mathbf{v}$ if $u_t \geq v_t$ for all t and $u_s > v_s$ for some s.

Following Koopmans (1960), independence conditions come in two forms. Firstly, by *Independent future* (**IF**), preference between streams that differ only from the second period on is the same as if the present time (period 1) was actually at period 2; i.e., as if generations {1,2,…} would have taken the place of generations {2,3,…}.

Condition IF *(Independent future)*: For any ${}_1\mathbf{u}, {}_1\mathbf{v} \in X$ with $u_1 = v_1$, ${}_1\mathbf{u} R_1 \mathbf{v}$ if and only if ${}_2\mathbf{u} R_2 \mathbf{v}$.

Secondly, by *Independent present* (**IP**), preference between streams that differ only in the first two periods does not depend on the continuation of the stream; i.e., the trade-off between the well-being of the first two generation is not influenced by the utility level of later generations.

Condition IP *(Independent present)*: For any ${}_1\mathbf{u}_2, {}_1\mathbf{v}_2 \in Y^2$, and ${}_3\mathbf{w}, {}_3\mathbf{x} \in X$, $({}_1\mathbf{u}_2, {}_3\mathbf{w}) R ({}_1\mathbf{v}_2, {}_3\mathbf{w})$ if and only if $({}_1\mathbf{u}_2, {}_3\mathbf{x}) R ({}_1\mathbf{v}_2, {}_3\mathbf{x})$.

Table 2: Important Ethical Conditions for Intergenerational Preferences

WP Weak Anonymity	Continuity / Compl. & transitive
SP Strong Pareto	Indep. future **IF** / **IP** Indep. present

Lastly, the so-called technical conditions include that the social preferences are complete and transitive, and continuous (relative to the sup norm topology). The ethical conditions as listed above are summarized in Table 2.

Consider now different kinds of criteria for intergenerational justice. The (Rawlsian) *maximin* criterion entails that

$$ {}_1\mathbf{u} \, R \, {}_1\mathbf{v} \text{ if and only if } \inf_{t \geq 1} u_t \geq \inf_{t \geq 1} v_t . $$

Hence, only the worst-off generation matters! This criterion is often associated with Rawls (1971) and it was applied in the intergenerational setting by Solow (1974). It is straightforward to demonstrate that maximin is a complete, transitive, and continuous criterion which satisfies condition **WA**, but not the efficiency and independence conditions, as summarized in Table 3.

Table 3: Maximin Satisfies …

WP Weak Anonymity	Continuity / Compl. & transitive
SP Strong Pareto	Indep. future **IF** / **IP** Indep. present

What if the worst-off generation matters most, but the second worst-off generation is used to resolve ties, and so on? This corresponds to a criterion which, in the literature, has been referred to as lexicographic maximin, or *leximin* for short. When applying leximin to the evaluation of intergenerational utility streams, it satisfies satisfies conditions **WA** and **SP**, as well as the independence conditions. However, leximin is neither complete nor continuous, as summarized in Table 4. The same conclusion holds for classical utilitarianism, as suggested by Ramsey (1928) and adapted to infinite utility streams by Atsumi (1965) and von Weizsäcker (1965):[4]

$$ {}_1\mathbf{u}\, R\, {}_1\mathbf{v} \text{ if and only if } \exists \hat{T} \text{ s.t. } \forall T \geq \hat{T},\ \sum_{t=1}^{T} u_t \geq \sum_{t=1}^{T} v_t . $$

Table 4: Leximin and Classical Utilitarianism Satisfy …

WP Weak Anonymity	Continuity / Compl. & transitive
SP Strong Pareto	Indep. future **IF** / **IP** Indep. present

Another possibility is to have that only the infinite future matters by, e.g., letting

$$ {}_1\mathbf{u}\, R\, {}_1\mathbf{v} \text{ if and only if } \liminf_{t\to\infty} u_t \geq \liminf_{t\to\infty} v_t . $$

This criterion satisfies all the conditions, except for condition **SP**, as summarized in Table 5. This is not an attractive ethical criterion, as it is insensitive for the well-being of generations $1, 2, 3, \ldots, T,$ independently of how large the finite

4 Why do not leximin and discounted utilitarianism satisfy continuity? To see this, let $v > u > w^1 > w^2 > w^3 > \ldots > x$ where $w^n \to x$ as $n \to \infty$, and consider the utility streams ${}_1\mathbf{u}^n = (u, w^n, w^n, w^n, \ldots)$, $n \in N$, and ${}_1\mathbf{v} = (v, x, x, x, \ldots)$. Both leximin and discounted utilitarianism imply that, for each $n \in N$, ${}_1\mathbf{u}^n P_1\mathbf{v}$, while by condition **SP** ${}_1\mathbf{v}$ is socially preferred to the utility stream that ${}_1\mathbf{u}^n$ approaches as $n \to \infty$, namely $(u, x, x, x, \ldots)$. This contradicts that leximin and discounted utilitarianism are continuous in the sup norm topology.

number T is chosen. In particular, it constitutes a *dictatorship of the future*, in the terminology of CHICHILNISKY (1996).

Table 5: If Only the Infinite Future Matters, then …

WP Weak Anonymity	Continuity Compl. & transitive
SP Strong Pareto	Indep. future **IF** **IP** Indep. present

Finally, *discounted utilitarianism* means that

$$_1\mathbf{u}\, R\, _1\mathbf{v} \text{ if and only if } \sum_{t=1}^{\infty} \delta^{t-1} u_t \geq \sum_{t=1}^{\infty} \delta^{t-1} v_t ,$$

where δ is the *factor* between 0 and 1 with which future utilities are discounted. This criterion satisfies all the conditions, except for condition **WA**, as summarized in Table 6. In fact, discounted utilitarianism is the only criterion that satisfies conditions **SP**, **IF**, and **IP**, as well as completeness, transitivity, and continuity. This characterization of discounted utilitarianism is very similar to the one given by KOOPMANS (1960). Since discounted utilitarianism discriminates future generations by discounting their utility, it does not treat generations equally, as required by condition **WA**, and it constitutes a *dictatorship of the present*, in the terminology of CHICHILNISKY (1996).

Table 6: Discounted Utilitarianism Satisfies …

WP Weak Anonymity	Continuity Compl. & transitive
SP Strong Pareto	Indep. future **IF** **IP** Indep. present

When going through the above mentioned ethical criteria for intergenerational utility streams, it is noteworthy that none of them satisfies all the conditions that have been introduced. In fact, no criterion can, as a consequence of result reported by Diamond (1965) (and which he attributes to M. E. Yaari): There exist no complete, transitive, and continuous (in the sup norm topology) social preferences satisfying conditions **WA** and **SP**, as summarized in Table 7. This points to a fundamental conflict between equity and efficiency. The technical conditions that Diamond (1965) requires entail that the intergenerational preferences can be numerically represented by a social welfare function. His result has subsequently been strengthened by Basu and Mitra, 2003a, who show that the assumption of numerical representability comes in conflict with conditions **WA** and **SP**, even without imposing continuity.

Table 7: No Social Preferences Satisfy …

WP Weak Anonymity	Continuity / Compl. & transitive
SP Strong Pareto	Indep. future **IF** / **IP** Indep. present

4. Solutions to an Ethical Dilemma

As reported in the previous section, it is impossible to combine the usual ethical conditions ensuring both efficiency and equity with a social welfare function that represents the intergenerational preferences. This constitutes an ethical dilemma. There are essentially two ways out of this dilemma:

1. Stick with conditions **WA** and **SP**, but do not insist on representability.
2. Stick with representability, but modify equity and efficiency conditions.

In relation to the first of these alternatives, it is important to note that conditions **WA** and **SP** are not incompatible by themselves, and it is of interest to explore the consequences of imposing these conditions. It is not too difficult to show that conditions **WA** and **SP** correspond to the *Suppes-Sen grading principle* (Suppes, 1966; Sen, 1970), whereby one utility stream is preferred to another if a finite permutation of the former Pareto-dominates the latter.

In ASHEIM, BUCHHOLZ and TUNGODDEN (2001) we show that the Suppes-Sen grading principle (and thus, conditions **WA** and **SP**) has far-reaching implications in technological environments that satisfy the following productivity condition:

A set of feasible utility streams satisfies productivity *if, for any feasible* ${}_1\mathbf{u}$ *with* $u_t > u_{t+1}$ *for some t, the utility stream* $(u_1, \ldots, u_{t-1}, u_{t+1}, u_t, u_{t+2}, \ldots)$ *is feasible and inefficient.*

Hence, if a utility stream is *not* non-decreasing – i.e., there exists some t such that $u_t > u_{t+1}$ – then it is possible to save the additional utility of generation t for the benefit of generation $t+1$ such that $t+1$'s gain is larger than t's sacrifice. By condition **WA** the new stream would have been socially indifferent to the old one even if the additional utility of t were transferred to $t+1$ without any net productivity (since this would have amounted to a permutation of the utilities of generations t and $t+1$). By condition **SP** it follows that the new stream is (strictly) preferred since $t+1$'s gain is larger than t's sacrifice.

This argument means that only non-decreasing utility streams are undominated by social preferences satisfying conditions **WA** and **SP** in technological environments satisfying our productivity condition. Since any non-decreasing utility stream is sustainable – according to any of the most common definitions of the notion of sustainable development – conditions **WA** and **SP** thus justify sustainability.

The DHS model (even with resource constraints; i.e., $\beta > 0$) is productive in the above sense. Hence, if the social preferences satisfy conditions **WA** and **SP**, then only efficient and non-decreasing utility streams are undominated. However, as I have already discussed in Section 2, discounted utilitarianism leads to optimal utility streams that are *not* non-decreasing, although efficient and non-decreasing utility streams exist (due to the assumption that $\alpha > \beta$). This entails that, in the DHS model with resource constraints, there are utility streams acceptable under social preferences satisfying conditions **WA** and **SP**, but such streams are not optimal under discounted utilitarianism. In contrast, efficient and non-decreasing utility streams may be optimal under discounted utilitarianism *without* resource constraints. Consequently, in such a technological environment, optimal utility streams under discounted utilitarianism need not be dominated under social preferences satisfying **WA** and **SP**. This may serve as formal support for the ethical intuition that discounted utilitarianism fails in a fundamental manner in the DHS model with resource constraints, although leading to attractive consequences in the same model without resource constraints.

Even though conditions **WA** and **SP** combined with *productivity* may justify sustainability, there exists the further problem concerning how to resolve distributional conflicts between generations that go beyond the sustainability question. However, as shown by BASU and MITRA (2003b), ASHEIM and TUNGODDEN (2004a), and BOSSERT, SPRUMONT and SUZUMURA (2005), it is possible to resolve such conflicts by introducing additional conditions, leading to characterizations of leximin and classical utilitarianism. On the one hand, such intergenerational preferences are appealing as they include the usual equity and efficiency conditions. On the other hand, they are both insensitive toward the information provided by either interpersonal level comparability or interpersonal unit comparability. Leximin makes no use of interpersonal unit comparability (even if utilities are unit comparable), while classical utilitarianism makes no use of interpersonal level comparability (even if utilities are level comparable).

Hence, it is of interest to explore a middle ground between utilitarian criteria and egalitarian criteria like maximin and leximin, with the aim of developing criteria for intergenerational justice that make non-trivial used of both level and unit comparability. This serves as a motivation for the analysis presented in ASHEIM and TUNGODDEN (2004b). There we follow the other ways out of the ethical dilemma posed in the beginning of this section, by sticking with representability, while modifying equity and efficiency conditions. Within a framework that resembles the one used by KOOPMANS (1960), we show that there exist representable social preferences that assign priority to the infinite number of future generations if the present is better off than the future, but trade off the interests of present and future generations in the reverse case. We thereby axiomatize social preferences that lead to ethically appealing outcomes in the DHS model with resource constraints, by allowing for development and thus preventing perpetual poverty, without leading to unacceptable inequalities.

5. Concluding Remarks

In this paper I have illustrated RAWLS' (1971) *reflective equilibrium* in the context of the social evaluation of infinite utility streams: criteria for intergenerational justice should not only be judged by the ethical conditions on which they build, but also by their consequences in specific environments.

I have shown how a discounted utilitarianism, while promoting appealing consequences in some technological environments, may lead to consequences indefensible from an ethical point in other environments.

I have also illuminated the conflict between equity and efficiency conditions, which have been a central theme in the axiomatic literature on intergenerational justice, and which represents an ethical dilemma in the social evaluation of infinite utility streams.

I have argued that there are ways out of this ethical dilemma. In particular, the existence of such a dilemma does not constitute a definitive case for discounted utilitarianism, which in the terminology of Chichilnisky (1996) represents a dictatorship of the present. Rather, as shown in recent contributions, there exist social preferences over infinite utility streams that protect the interests of future generations, while retaining sensitivity for the interests of the present.

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SUMMARY

When evaluating long-term policies, economists usually suggest to maximize the sum of discounted utilities. On the one hand, discounted utilitarianism was given a solid axiomatic foundation by Koopmans (Econometrica 1960). On the other hand, this criterion has questionable implications when applied to economic models with resource constraints. This raises the question: What ethical conditions for intergenerational distribution should and can be imposed? I use my discussion of such conditions to illuminate the conflict between equity and efficiency that has been a central theme in the axiomatic literature on intergenerational justice. Moreover, a guide to some recent contributions is presented.

ZUSAMMENFASSUNG

Bei der Evaluation von langfristigen Politikmassnahmen schlagen Ökonomen meist die Maximierung der Summe der diskontierten individuellen Nutzen vor. Einerseits lieferte Koopmans (Econometrica 1960) eine solide axiomatische Grundlage für den diskontierten Utilitarismus. Anderseits hat dieses Kriterium jedoch fragwürdige Implikationen wenn man es auf ökonomische Modelle mit Ressourcenknappheit anwendet. Dies wirft die Frage nach den ethischen Grundlagen für die intergenerationelle Verteilung auf, welche durchgesetzt werden sollten und können. Ich verwende meine Diskussion solcher Bedingungen, um den Konflikt zwischen Gerechtigkeit und Effizienz zu erhellen, welcher ein zentrales Thema der axiomatischen Literatur über intergenerationelle Gerechtigkeit ist. Zusätzlich wird ein Überblick der neueren Literaturbeiträge gegeben.

RÉSUMÉ

En évaluant les politiques à long terme, les économistes suggèrent le plus souvent de maximiser la somme des utilités escomptées. D'un côté, l'utilitarisme escompté a reçu une solide fondation axiomatique par Koopmans (Econometrica 1960). De l'autre côté, ce critère a des implications douteuses quand il est appliqué aux modèles économiques avec un manque de ressources. Quelles conditions pour la distribution intergénérationelle devraient et peuvent alors être imposées? J'utilise dans ma recherche ces conditions pour illustrer le conflit entre justice et efficience, qui a été un thème central dans la littérature axiomatique sur la justice intergénérationelle. Par ailleurs, l'article présente un survol des récentes contributions de la littérature.