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A utilitarian notion of responsibility for sustainability

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Abstract: We develop and formalize a utilitarian notion of responsibility for sustainability which is inspired by Singer's (1972) principle and the Brundtland Commission's notion of sustainability (WCED 1987). We relate this notion of responsibility to established criteria for the assessment of intertemporal societal choice, namely Pareto-efficiency, (discounted) utilitarian welfare maximization, and Brundtland-sustainability. Using a two-generations-resource-model, we find the following. Sustainability and responsibility for sustainability are equivalent if and only if sustainability is feasible. If it is not, there still exists a responsible allocation which is also Pareto-efficient. Further, the utilitarian welfare maximum without discounting always fulfills the criterion of responsibility. Discounting may be responsible to a certain extent if sustainability is feasible. If sustainability is not feasible, discounting is not responsible.

JEL Classification: D63, D90, Q01, G56

Keywords: basic needs, Brundtland, discounting, ethics, natural resources, Pareto efficiency, responsibility, Singer, sustainability, utilitarianism

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1 Introduction

Sustainability is a very broad conception of justice. As such it poses an imperative on presently living persons. This imperative of sustainability implies intra- as well as intergenerational justice. More specifically, as defined by the Brundlandt Commission (WCED 1987), sustainability refers to the satisfaction of basic needs of present and future generations. To realize sustainability, presently living persons ought to act sustainably which implies at least two obligations: one directed towards the present generation and the other towards future generations.

Acting sustainably means to take specific actions in accordance with the norm of sustainability in a concrete action context (Baumgärtner et al. 2010). An action context is characterized by a feasible set of actions, given system structure and dynamics, and knowledge of the system. This may create a gap between the general and abstract imperative to act sustainably, and the specific action context since the set of feasible actions and the knowledge of the system may be limited. This paper aims to fill this gap by conceptualizing a person's *responsibility* for sustainability.

The concept of responsibility – as it has emerged from modern practical philosophy, political science, and law – links abstract norms with specific action contexts (Baumgärtner et al. 2010). It is gaining importance in the normative assessment of public policy-making as well as of private decision-making, since the impacts of human actions have increased dramatically in modern times (Jonas 1979). Some impacts are irreversible and occur at remote places or far in the future, such as e.g. anthropogenic climate change or biodiversity loss. Furthermore, action contexts are often characterized by uncertainty and unidirectional power structures.

One crucial feature of responsibility is that it is limited – namely by the acting person's possibility of compliance as well as by the need to balance a plurality of normative obligations. Therefore, the imperative of sustainability cannot imply an absolute obligation to attain a particular (sustainable) state or development of the world. It does imply, though, a relative obligation to do one's best to live up to the challenge of sustainability. The crucial question of responsibility, then, is: what exactly does "one's best" mean?

In this paper, we develop and formalize a utilitarian notion of responsibility for sustainability which is inspired by Singer's (1972) principle and the Brundtland Commission's notion of sustainability (WCED 1987). To illustrate the meaning of the utilitarian notion of responsibility thus developed, we apply it in a simple model and relate it to established criteria for the normative assessment of intertemporal societal choice, namely Pareto-efficiency, (discounted) utilitarian welfare maximization, and Brundtland-sustainability. The model comprises two non-overlapping generations. They share a natural resource from which they produce a consumption good that allows them to satisfy their basic needs and wants. We thus model a simple resource allocation problem, yet with a unidirectional power structure: the first generation can decide which share of the resource to

use for itself and which share to hand over to the second generation. This simple setup allows us to analyze and compare which allocations satisfy different normative criteria.

This study adds to the economic literature about responsibility. The normative strand of the literature focuses predominantly on retrospective responsibility, that is "the idea that individuals are or should be held responsible, to some degree, for their achievements" (Fleurbaey 2008: 1). We follow the idea of forward-looking responsibility in the sense of an obligation (as in Baumgärtner et al. 2006) and sharpen this idea as we formally implement it in economic modeling. Besides normative implications of responsibility, there further exists a descriptive strand in the literature, which analyzes the implications of individuals wanting to assume responsibility for the public good (e.g. Frey 1997, Brekke et al. 2003, Nyborg and Rege 2003, Heyes and Kapur 2011).

Our results show that sustainability and responsibility for sustainability are equivalent if and only if sustainability is feasible. If it is not, there still exists a responsible allocation which is also Pareto-efficient. Further, the utilitarian welfare maximum without discounting always fulfills the criterion of responsibility. Discounting may be rsponsible to a certain extent if sustainability is feasible. If sustainability is not feasible, discounting is not responsible. At a more general level, we demonstrate that responsibility can be formalized in economic models which adds specificity to the discussion about normaitve conceptions such as sustainability.

The paper is organized as follows. Section 2 defines and discusses the concepts of sustainability and responsibility, thus preparing the conceptual, normative basis for the analysis. Section 3 introduces the model. Section 4 gives formal definitions and characterizations, through necessary and sufficient conditions, of the normative criteria. Section 5 presents our results. Section 6 concludes.

2 Conceptual foundations

Sustainability

Sustainability, as we understand it, is a very broad conception of justice. It combines the ideas of global intragenerational justice and of intergenerational justice, and often also includes justice towards nature. We apply a specific anthropocentric notion of sustainability, namely the Brundtland Commission's definition: "Sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987: 43). This definition includes elements of intra- and intergenerational justice but not towards nature. It is anthroprocentric and implies that only human beings deserve moral attention. By "generation" it thus refers to all human beings living at the same time period.[1] Furthermore, Brundtland-sustainability is in part result-oriented as it aims at the satisfaction of basic needs of the present generation, and in part prerequisite-oriented as it aims at maintaining the future ability to satisfy basic needs. In this

[1] From now on, we use the term "generation" in that sense.

paper, we focus on the aspect of intergenerational justice. However, our analysis can just as well be applied to intragenerational justice.

The term "basic needs" requires further specification.[2] In the Brundtland-definition it is further specified as "[…] the essential needs of the world's poor, to which overriding priority should be given" (WCED 1987: 43). Such basic needs include two elements. First, they include certain minimum requirements of a family for private consumption: adequate food, shelter and clothing are obviously included, as would be certain household equipment and furniture. Second, they include essential services provided by and for the community at large, such as safe drinking water, sanitation, public transport, and health and educational facilities" (ILO 1976: 32). For our analysis, a crucial assumption is that at least some basic needs "can be set on the basis of scientific findings" (ILO 1976: 33) and that essential, "[…] fundamental human needs are finite, few and classifiable; and […] fundamental human needs […] are the same in all cultures and in all historical periods" (Max-Neef 1991: 18). These assumptions ensure the applicability of Singer's principle in the context of intergenerational justice.

Being a conception of justice, Brundtland-sustainability defines legitimate claims of present and future generations with respect to the satisfaction of their basic needs. Thereby, it poses an imperative on presently living persons. Such persons ought to act in accordance with the norm of sustainability, that is, they ought to act such as to fulfill all these legitimate claims. Taking a specific action always occurs in a concrete action context in which there exists a set of feasible actions and in which knowledge about given system structures and dynamics are crucial to choose actions that deliver desired outcomes. There thus exists a gap between the abstract norm of sustainability and the specific action context, which needs to be closed in economic thinking and modelling.

Responsibility

This gap can be closed with the concept of responsibility. Responsibility is a multifarious notion. In the philosophical discussion of responsibility, at least three different aspects of the notion have been distinguished. (1) The primary meaning of responsibility is being the perpetrator of one's own actions, that is, "[…] one ascribes an action to oneself and allows for it to be thus ascribed" (Baumgärtner et al. 2006: 227). The primary meaning is purely descriptive and has no moral relevance by itself. It simply states that *A* is responsible for *X* if and only if *A* is the perpetrator of *X*.[3] This is a precondition of morality, as one can only be morally praised or blamed for an action that can be ascribed to oneself.

(2) Often, we use 'responsibility' as a synonym for obligation (Williams 2008: 458). This is what Baumgärtner et al. (2006) call the secondary meaning of responsibility. In this meaning, responsibility attains a moral significance when obligations exist which a person

[2] We use the terms "basic" needs, "essential" needs and "fundamental" needs synonymously.

[3] The related and no less relevant question of which (future) consequences of one's action can be ascribed to oneself poses a number of intricacies in a world where several actors interact and there are stochastic influences on system dynamics (Vallentyne 2008).

morally has to accept, that is, *A* ought to do *X* (positive responsibility) or ought not to do *X* (negative responsibility) for moral reasons. Such obligations arise for different reasons, one of which are the legitimate claims that some claim holders have due to principles of justice. In view of Brundtlad-sustainability, there exists a positive responsibility (in the sense of: obligation to fulfill a legitimate claim), namely to satisfy the basic needs of the present generation, and a negative responsibility, namely to not compromise the ability of future generations to satisfy their basic needs.

(3) Williams (2008) defines a third meaning of responsibility: "Responsibility represents the readiness to respond to a plurality of normative demands" (Williams 2008: 459). In other words, responsibility is important whenever a person is facing a plurality of normative obligations. This becomes relevant for sustainability as the Brundtland-notion of sustainability contains two obligations: satisfying the basic needs of the present generation and not compromising the ability of future generations to satisfy their needs.

Our notion of responsibility for sustainability encompasses these three meanings. That is, our notion of responsibility is not purely descriptiv (primary meaning) but is essentially normative, as it refers to an oblication that arises from some principles of justice (secondary and third meaning).

To further sharpen this notion of responsibility, we need to specify who bears responsibility for sustainability. In general, this could be every member of the present generation, e.g. an individual, a group of individuals, a corporation, a nation state and so on. The minimum requirement for being responsible is to be a person-like entity. Locke (1959: 264) defines a person as[4] "[a] thinking intelligent being that has reason and reflection and can consider itself as itself, the same thinking thing, in different times and places." A person or a person-like entity[5] is thus defined by intelligence, capacity for reason, self-awareness and consciousness of time and space. With our focus on sustainability as intergenerational justice, we consider only presently living persons to bear responsibility for Brundtland-sustainability, while the whole present generation[6] and all future generations have legitimate claims due to Brundtland-sustainability.

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[4] Locke's idea of what constitutes a person is not undisputed (see Gertler 2010 for a discussion). Yet, it fits well with Singer's understanding of a person.

[5] From here on, we use the term "person" in a broad sense including all "person-like entities" which satisfy Locke's definition.

[6] Note that the two groups of (1) the presently living generation, who holds legitimate claims to the satisfaction of their basic needs according to Brundtland-sustainability, and (2) the presently living persons or person like entities, who bear responsibility for sustainability, do not need to be indentical. There may be members of the present generation who are not persons, and there may be persons who are not members of the present generation. As an example of the former, a presently living human infant has according to Brundtland-sustainability a legitimate claim that her basic needs are satisfied, because she is part of the present generation. However, we do not consider an infant as a responsible person, because she has not yet developed all characteristics of a person, such as reason and reflection. As an example of the latter, a business corporation that can be considered as

As we have now defined the subject (presently living persons), object (basic needs of present and future generation) and justification (sustainability as justice) of our notion of responsibility, we proceed with discussing the extent of responsibility. What are the limits of a person's responsibility for sustainability? There are two fundamental limits.

The first limit is the widely endorsed 'ought-implies-can' criterion according to which one can be only obliged to do what one actually can do.[7] Its rationale is that responsibility presupposes the possibility of compliance: "[a]ction-guiding principles must fit human capacities, or they become strange in a damaging way: pointless" (Griffin 1992: 123). The possibility of compliance implicates that a person has the power and the knowledge to comply. The power to comply refers to physical and mental abilities of the person as well as to the availability and effectiveness of instruments or resources. For example, imagine the situation of a drowning child. We do not hold a person responsible to save the child who is unable to swim, who is mentally paralyzed or who has no means to call somebody else to save the child. The knowledge to comply refers to situations in which a person cannot know the legitimate claims of others or the implications of her actions. In the example, a person cannot be held responsible to save the drowning child if she cannot know that the child is actually drowning. Hence, power and knowledge limit one's responsibility as they delineate the possibility of compliance. In this paper, we focus on the power to comply, as defined by a limited set of feasible actions, and leave questions related to knowledge for future research.[8]

The second limit concerns the legitimate claims of the person who bears responsibility. Conceptions of justice define legitimate claims of some individuals or collectives. In the case of Brundtland-sustainability, each member of the present and of future generations has a legitimate claim with respect to the satisfaction of his or her basic needs. To satisfy this claim is the responsibility of persons of the present generation. However, these persons have the same legitimate claim with respect to their own basic needs. It follows that there may arise a conflict between the obligation for the satisfaction of basic needs of others and the obligation for the satisfaction of one's own basic needs. But how exactly do the legitimate claims of a responsible person limit the responsibility for fulfilling the legitimate claims of others? An answer to this question is given by Singer's principle.

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a person-like entity because it has all the chartacteristics of a person (hence the name: "corporation") and, therefore, bears responsibility for sustainability, does not have any legitimate claim to the satisfaction of its "basic needs" because these are only defined for individual human beings.

[7] The ought-implies-can criterion goes back at least to Kant who maintained that responsibility as a duty or obligation presupposes the possibility of compliance: "it would not be a duty to strive after a certain effect of our will if the effect were impossible in experience" (Kant 1991: 62). Contemporary philosophers, such as Singer (1993) or Griffin (1992), argue in a similar way that it would be "absurd to say that we ought to do what we cannot do" (Singer 1993: 242).

[8] Krysiak (2009) discusses responsibility – yet, only in the primary menaing (i.e. ascription of consequences to actors) – for the case in which a present actor acts under uncertainty.

Singer's principle

The utilitarian ethicist Singer starts with the normative assumption that suffering – e.g. from lack of shelter or food or, more generally, from unsatisfied basic needs – is something bad. Singer's principle then states that "if it is in our power to prevent something bad from happening, without thereby sacrificing anything of comparable moral importance, we ought, morally, to do it" (Singer 1972: 231). With "we", Singer refers to persons in the sense of Locke (1959) as defined above. Hence, all persons are responsible to prevent suffering of others, e.g. from unsatisfied basic needs.

A crucial idea of Singer's principle is that the claims of a responsible person are legitimate in limiting this responsibility only to the extent that they are "of comparable moral importance". For instance, claims to consume cars, clothes, shoes, or concerts are, according to Singer, *not* of comparable moral importance compared to the basic needs of suffering persons. It follows that the obligation to prevent or remedy the suffering of others holds insofar as the responsible person is not also suffering from unsatisfied basic needs. More specifically, Singer defines that a responsible person ought to give[9] "to the point of marginal utility, at which by giving more one would cause oneself and one's dependents as much suffering as one would prevent […]" (Singer 1972: 234). The point of marginal utility hence provides an explicit definition of the relation of legitimate claims of the responsible person and of those of other suffering persons. Responsibility for the latter extends up to the point where positive and negative marginal effects of giving more are equal.

Singer's principle is a modified version of the utilitarian principle. It differs from standard utilitarianism as it states that minimizing suffering is morally more important than maximizing the satisfaction of wants, thus introducing a lexicographic ordering. In this sense, it is very well suited to specify the limits of responsibility for Brundtland-sustainability, as the latter only defines that basic needs should be satisfied and not what ought to be done beyond that point.

To apply the principle in the context of Brundtland-sustainability, we make the normative assumption that unsatisfied basic needs of present and future generations are something bad. All members of present and future generations suffer when their basic needs are not satisfied. With this assumption, we apply Singer's principle and limit the responsibility of present persons to act responsibility by the point of marginal utility, at which by saving more resources for future generations present persons would cause themselves as much suffering as they would prevent in future generations.

Utilitarian notion of responsibility for sustainability

To sum up, the imperative of sustainability cannot imply an absolute obligation to attain a particular (sustainable) state or development of the world. It does imply, though, the responsibility to use the best available knowledge and power to, according to Brundtland

[9] Singer discusses the context in which a person can remedy suffering of others by "giving" a donation. Hence his wording.

(WCED 1987), meet the needs of the present generation without compromising the ability of future generations to meet their needs. Our utilitarian notion of responsibility for sustainability can be summarized as follows:

Presently living persons are responsible for *meeting the basic needs* of the present generation and *not compromising the ability* of future generations to meet their basic needs to the extent of *presently living persons*' *possibility of compliance* and to the point of *marginal utility*.

3 Model

There are two non-overlapping generations t =1,2.[10] Both have preferences over consumption C_t, represented by a utility function $U_t(C_t)$ which is characterized by positive and decreasing marginal utility. In the utility function, there is a distinction between consumption below and above a level C^{BN} at which basic needs are satisfied. C^{BN} is identical for both generations, normalized to 1, and yields a utility level $U_t\left(C^{\mathrm{BN}}\right) = U_t^{\mathrm{BN}}$.

We further assume that to the extent that their basic needs are not yet satisfied, that is for $C_t \leq C^{\mathrm{BN}}$, both generations have identical preferences. In terms of Singer's ethics, unsatisfied basic needs means that persons are suffering. The assumption thus states that any further unit of food, shelter or medicine has the same marginal effect on every suffering person. In other words, we assume persons to be equal in their suffering. Beyond the threshold where basic needs are met, that is for $C_t > C^{\mathrm{BN}}$, their preferences may or may not be identical. Our assumption of identical preferences below the basic needs level and diverging preferences beyond that point is in line with e.g. the arguments of Partridge (2003) who states that "[…] it is much easier to identify and address the causes of misery, than to promote the wellsprings of happiness. This is especially so with regard to the future. Their pains and ours can be traced to our common somatic needs and the status of the planetary ecosystem which sustains us both. Their pleasures and satisfactions will come from developments in culture, taste and technology that we cannot even imagine."

The utility functions are given by:

$$U_t(C_t) = \begin{cases} C_t^{\alpha} & \text{for } C_t \leq C^{\mathrm{BN}} \quad \text{for } t = 1,2 \\ C_t^{\alpha_t} & \text{for } C_t > C^{\mathrm{BN}} \quad \text{for } t = 1,2 \end{cases}, \tag{1}$$

with $0 < \alpha_t < \alpha < 1$. Marginal utility from consumption is thus strictly larger if the basic needs are not met than if they are met. The utility functions are depicted in Figure 1:

[10] For simplification, we assume that each generation consists of one representative person.

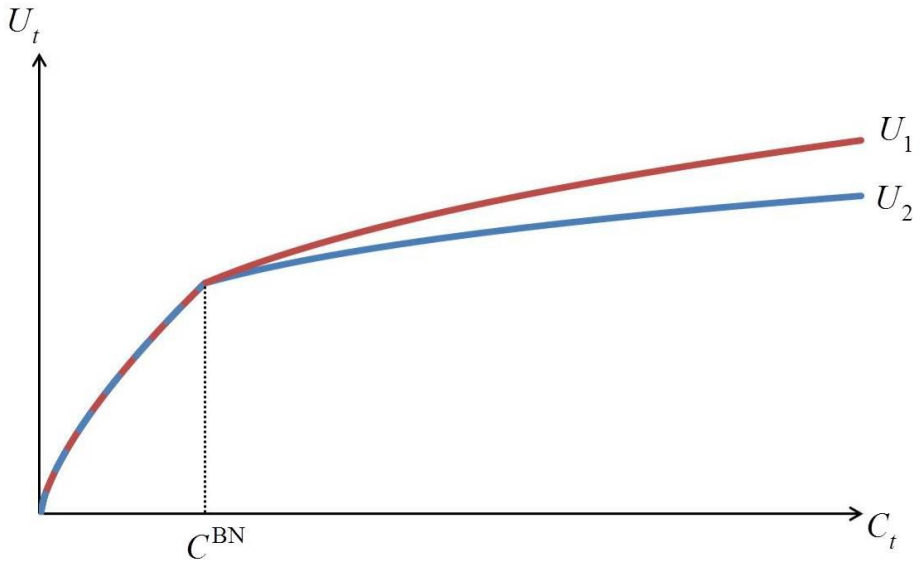

Figure 1: Utility functions

Consumption is being generated from the (consumptive) use of a resource stock $\overline{R} > 0$. This stock can be allocated between both generations such that each generation t (t = 1,2) has an endowment R_t:

$$R_1 + R_2 \leq \overline{R} \,. \tag{2}$$

Each generation has a simple linear production technology represented by the function:

$$C_1(R_1) = R_1 \,, \tag{3}$$

$$C_2(R_2) = \gamma R_2 \,. \tag{4}$$

$\gamma > 0$ is an exogenous factor which can be broadly interpreted: either as productivity change or as natural renewability/growth of the resource. There is no waste in production such that every unit produced will be consumed.

With these assumptions, there exists a minimal resource endowment $R^{\min}$ which exactly allows both generations to satisfy their basic needs:

$$R^{\min} = 1 + \frac{1}{\gamma} \,. \tag{5}$$

4 Definitions

Within this model, we now define resource allocations (R_1, R_2) to be sustainable, responsible, Pareto-efficient, and Discounted-utilitarian-welfare-maximal. Further, we characterize each of these resource allocations with necessary and sufficient conditions. An allocation is *feasible* if the sum of the resource endowments is not larger than the total resource stock $\overline{R}$ (Eq. (2)).

In line with the Brundtland-conception (WCED 1987), sustainable allocations are defined as meeting the basic needs of both generations.

Definition 1 (Sustainable allocations)

A feasible allocation (R_1, R_2) is called *sustainable* if and only if it yields for all t =1,2

$$C_t(R_t) \geq C^{\mathrm{BN}} = 1 \,. \tag{6}$$

With this definition, sustainable allocations are characterized as follows.

Lemma 1

A feasible allocation (R_1, R_2) is *sustainable* if and only if it meets the following conditions:

$$R_1 \geq 1 \text{ and } R_2 \geq 1/\gamma \tag{7}$$

The conditions for sustainable allocations are intuitive: both generations need a minimal resource endowment, as defined by Eq. (7), to be able to satisfy their basic needs. The minimal endowment of the second generation is contingent on γ. If γ is large (e.g. due to high technological progress or natural resource growth), the second generation needs a small share of the resource. A small γ (e.g. due to ecological degradation) requires a large resource share for the second generation. Further, Eq. (7) shows that existence of sustainable allocations requires that $\overline{R} \geq R^{\min}$.

Applying our notion of responsibility developed in Section 2 to this notion of sustainability, we continue with the formal definition and necessary and sufficient conditions of responsible allocations.

Definition 2 (Responsible allocations)

A feasible allocation (R_1,R_2) is called *responsible* if and only if it yields for all t =1,2

$$C_t(R_t) \geq C^{\mathrm{BN}} = 1 \quad \text{for } \overline{R} \geq R^{\min}, \tag{8}$$

$$\frac{\mathrm{d}U_1\big(C_1(R_1)\big)}{\mathrm{d}C_1}\frac{\mathrm{d}C_1(R_1)}{\mathrm{d}R_1} = \frac{\mathrm{d}U_2\big(C_2(R_2)\big)}{\mathrm{d}C_2}\frac{\mathrm{d}C_2(R_2)}{\mathrm{d}R_2} \text{ and } \overline{R} = R_1 + R_2 \quad \text{for } \overline{R} < R^{\min}. \tag{9}$$

Our definition of responsible allocations distinguishes situations in which it is feasible to satisfy the basic needs of both generations (Eq. (8)), and situations in which this is not feasible (Eq. (9)). If it is feasible, obviously all allocations in which basic needs of both generations are satisfied, are responsible. However, if the resource stock is too small, there still exists a responsible allocation: the whole resource stock must be allocated such that there are equal marginal utilities from consumption. This ensures that suffering in the sense of Singer is minimized.

With this definition, responsible allocations are characterized as follows.

Lemma 2

A feasible allocation (R_1,R_2) is *responsible* if and only if it meets the following conditions:

$$R_1 \geq 1 \text{ and } R_2 \geq 1/\gamma \quad \text{for } \overline{R} \geq R^{\min}\,, \tag{10}$$

$$R_1 = \gamma R_2 \text{ and } \overline{R} = R_1 + R_2 \quad \text{for } \overline{R} < R^{\min} . \tag{11}$$

Lemma 2 shows that in the characterization of responsible allocations one needs to distinguish two cases: one (Eq. (10)) in which attaining the underlying normative aim (here: sustainability) is feasible, and one (Eq. (11)) in which it is not.

Now we define Pareto-efficient allocations.

Definition 3 (Pareto-efficient allocations)
A feasible allocation (R_1,R_2) is called *Pareto-efficient* if and only if there does not exist another feasible allocation (R_1', R_2') such that $U_t\big(C_t(R_t')\big) \geq U_t\big(C_t(R_t)\big)$ for all t =1,2 and $U_t\big(C_t(R_t')\big) > U_t\big(C_t(R_t)\big)$ for at least one *t*.

With this definition, Pareto-efficient allocations are characterized as follows.

Lemma 3
A feasible allocation (R_1,R_2) is *Pareto-efficient* if and only if it meets the following condition:

$$\overline{R} = R_1 + R_2 . \tag{12}$$

Since our model consists of one resource which can only be transformed into one good, and there are no externalities, all allocations which use the entire resource stock $\overline{R}$ must be Pareto-efficient.

Next we define allocations which are a discounted-utilitarian-welfare maximum.

Definition 4 (Discounted-utilitarian-welfare maximum)
A feasible allocation (R_1, R_2) is called a *discounted-utilitarian-welfare maximum* if and only if it solves:

$$\max_{R_1,R_2} W = U_1\big(C_1(R_1)\big) + \delta U_2\big(C_2(R_2)\big) \text{ s.t. } \overline{R} = R_1 + R_2 \tag{13}$$

In this definition, $\delta \geq 0$ is a discount factor which is the weight of the utility of the second generation in the overall welfare function. The special case of $\delta = 1$ means that no discounting takes place.

With this definition, discounted-utilitarian-welfare maxima are characterized as follows.

Lemma 4
A feasible allocation (R_1, R_2) is a *discounted-utilitarian-welfare maximum* if and only if it meets the following condition:

$$\alpha_1 (R_1)^{\alpha_1} = \delta \alpha_2 (\gamma R_2)^{\alpha_2} \text{ and } \overline{R} = R_1 + R_2 \quad \text{for } \overline{R} \geq R^{\min}, \tag{14}$$

$$(R_1)^{\alpha} = \delta (\gamma R_2)^{\alpha} \text{ and } \overline{R} = R_1 + R_2 \quad \text{for } \overline{R} < R^{\min}. \tag{15}$$

Discounted-utilitarian-welfare maxima are characterized by equal discounted marginal utility of both generations. Marginal utility of the second generation is weighed differently by the discount factor than marginal utility of the first generation.

Our analysis adds to the discussion about the ethical legitimacy of discounting. In general, there are three reasons for discounting (Gollier 2010). First, there is individual or societal impatience or pure time preference. Yet, ever since Pigou (1920) it is clear that while this argument may describe actual human behavior, it cannot be used normatively to justify discounting. Second, there is the assumption of decreasing marginal utility and future economic growth (Ramsey 1928). If there is higher consumption available in the future due to economic growth, and if marginal utility is decreasing with the level of consumption, intergenerational equity allows for discounting. Third, uncertainty about future outcomes allows for discounting as it makes future well-being uncertain. All taken together, there seems to be some ethical legitimacy in discounting, also in normative criteria of societal choice, at least to a certain extent.

5 Results

In this section, we present our results. First, we discuss the properties of responsible allocations. Further, we relate the necessary and sufficient conditions for responsible allocations with the conditions for sustainable, Pareto-efficient, and discounted-utilitarian-welfare maximum allocations.

Proposition 1 (Reponsibility)
If $\overline{R} \geq R^{\min}$, there exist infinitely many responsible allocations, characterized by Condition (10). If $\overline{R} < R^{\min}$, there exists a single responsible allocation, characterized by Condition (11).

Proof: Eq. (10) shows that there are infinite responsible allocations iff $\overline{R} \geq R^{\min}$. Eq. (11) shows that there exists one responsible allocation iff $\overline{R} < R^{\min}$.

This means, that in any case there exists a responsible allocation. If sustainability is feasible, that is if $\overline{R} \geq R^{\min}$, there exist infinitely many responsible allocations. This is due to the Brundtland notion of sustainability which is blind for distributional aspects once all basic needs are satisfied. Our notion of responsibility adds to this as it defines one responsible allocation for $\overline{R} < R^{\min}$ when sustainability is not feasible. At this allocation, $\overline{R}$ must be used completely ($\overline{R} = R_1 + R_2$) and marginal utilities from consumption must be equal as required by Singer's principle (which is the case for $R_1 = \gamma R_2$).

Proposition 2 (Sustainability)
If $\overline{R} \geq R^{\min}$, each responsible allocation is also sustainable, and vice versa. In contrast, if $\overline{R} < R^{\min}$, the responsible allocation is not sustainable. Responsibility for sustainability is, hence, equivalent to sustainability if and only if sustainability is feasible.

Proof: Eq. (10) shows that there are infinitely many responsible allocations for $\overline{R} \geq R^{\min}$. Comparison of Eq. (7) with (10) shows that all allocations satisfying Eq. (10) must also satisfy Eq. (7). Comparison of Eq. (7) with (11) shows that an allocation satisfying Eq. (11) cannot satisfy Eq. (7). □

Our model illustrates the common and diverging properties of the criteria of sustainability and of responsibility for sustainability. They are equivalent whenever sustainability is feasible. If it is not, they differ since then a responsible allocation exists while a sustainable allocation does not exist. The criterion of responsibility thus provides action guidance even if it is not feasible to attain the underlying normative objective (here: sustainability).

Proposition 3 (Pareto-efficiency)
If $\overline{R} \geq R^{\min}$, there exist some responsible allocations which are also Pareto-efficient. These are characterized by

$$\overline{R} = R_1 + R_2 \text{ and } R_1 \geq 1 \text{ and } R_2 \geq 1/\gamma\,. \tag{16}$$

Neither are all responsible allocations Pareto-efficient nor are all Pareto-efficient allocations responsible. If $\overline{R} < R^{\min}$, the responsible allocation, which is characterized by Condition (11), is Pareto-efficient.

Proof: Comparison of Eq. (12) with (10) shows that some but not all allocations satisfying Eq. (10) also satisfy Eq. (12), e.g. $R_1 = 1$ and $R_2 = 1/\gamma$ for $\overline{R} > R^{\min}$ satisfies Eq. (10) but not Eq. (12) while all $R_1 = 1 + \varepsilon$ and $R_2 = 1/\gamma$ for $\overline{R} = R^{\min} + \varepsilon$ with $\varepsilon \geq 0$ satisfy Eq. (10) and Eq. (12). Comparison of Eq. (12) with Eq. (11) shows that an allocation satisfying Eq. (11) also satisfies Eq. (12), as Eq. (12) is part of Eq. (11). But not all allocations satisfying Eq. (12) satisfy Eq. (11), e.g. $R_1 = 1 - \varepsilon$ and $R_2 = 1/\gamma$ for $\overline{R} = R^{\min} - \varepsilon$ with $\varepsilon \geq 0$. Eq. (16) follows straightforwardly from Eq. (12) and Eq. (7). □

Since the Brundtland notion of sustainability does not require Pareto-efficiency, the criterion of responsibility for sustainability does not require Pareto-efficiency if and only if sustainable allocations are feasible. The Brundtland notion merely defines a minimum standard and allows for wasteful allocations once the standard is achieved.

If sustainability is not feasible, the criterion of responsibility requires Pareto-efficiency in order to minimize suffering in the sense of Singer.

Proposition 4 (Discounted-utilitarian-welfare maximum)
There uniquely exists a discounted-utilitarian-welfare maximum, characterized by Condition (14) or (15). If no discounting takes place, $\delta = 1$, the discounted-utilitarian-welfare-maximum allocation is responsible. If, in contrast, discounting takes place, $\delta \neq 1$, the following holds:

For $\overline{R} \geq R^{\min}$, the discounted-utilitarian-welfare maximum is a responsible allocation iff

$$\delta^{\min} \leq \delta \leq \delta^{\max}. \tag{17}$$

with $\delta^{\min} = \frac{\alpha_1}{\alpha_2}\left(\overline{R} - \frac{1}{\gamma}\right)^{\alpha_1 - 1}$ and $\delta^{\max} = \frac{\alpha_1}{\alpha_2}\left(\gamma(\overline{R} - 1)\right)^{1-\alpha_2}$.

For $\overline{R} < R^{\min}$, the discounted-utilitarian-welfare maximum is not a responsible allocation.

Proof: For $\delta = 1$, comparison of Eq. (15) with Eq. (10) shows that all allocations satisfying Eq. (15) must also satisfy Eq. (10). The same holds for Eq. (14) and Eq. (10) since $\alpha_t < \alpha$ for all t =1,2. For $\delta \neq 1$, using $R_2 \geq 1/\gamma$ from Eq. (10) and $R_1 \geq 1$ in Eq. (14) yields Eq. (17). Comparison of Eq. (15) with Eq. (11) shows that an allocation satisfying Eq. (15) cannot satisfy Eq. (11). □

Let us first discuss the case without discounting, that is $\delta = 1$. If the resource stock is large enough ($\overline{R} \geq R^{\min}$) so that sustainable allocations exist, the discounted-utilitarian-welfare maximum must be sustainable and responsible since marginal utility of both generations is strictly larger when the basic needs are satisfied (see Eq. (1)). Any non-sustainable allocation, therefore, cannot be a discounted-utilitarian-welfare maximum. As there exist infinitely many sustainable and responsible allocations in this case, the discounted-utilitarian-welfare maximum is merely one out of many responsible allocations. If no sustainable allocations exist (i.e. $\overline{R} < R^{\min}$), Singer's principle requires that responsible allocations minimize suffering which is simply a negative formulation of maximizing happiness and thus of the principle of Utilitarianism. It follows that the responsible allocation in this case must be a discounted-utilitarian-welfare maximum.

Now, let us discuss discounting, that is $\delta \neq 1$. Discounting yields a sustainable and responsible allocation if and only if there exist sustainable allocations and the discount rate is within the range specified by Condition (17). The intuition is as follows. The Brundtland notion of sustainability merely defines a minimum standard of sustainability as satisfied basic needs. If this standard is feasible, discount rates that do not favor any generation too strongly yield sustainable allocations. Discount rates not satisfying Condition (17) however, yield allocations in which the basic needs of one generation cannot be satisfied and which are thus neither sustainable nor responsible.

The range specified by Condition (17) has the following intuitive properties. Intuitively, large technological progress (γ) allows for larger discounting of future utility to be responsible. A large resource stock ($\overline{R}$) allows for a large discounting in general. Further, a large (small) ratio of α_1/α_2 allows for larger (smaller) discounting of future utility to be responsible, as it implies that marginal utility of the first generation is higher than of the second generation.

If the resource stock is so small ($\overline{R} < R^{\min}$) that no sustainable allocation exists, discounting is not responsible. Any unequal valuation of utility between generations will not minimize suffering and, therefore, cannot be responsible. This result is interesting in light of the two ethically acceptable arguments for discounting: consumption growth with decreasing marginal utility, and uncertainty.

The argument of growth with decreasing marginal utility cannot be upheld in favor of discounting if sustainability is not feasible, because it is already included in the criterion of equal marginal utility. If there is growth in terms of a large γ, Eq. (11) shows that this yields a larger resource share for the first generation in the responsible allocation. Any further discounting can thus not be justified with this argument.[11] The case of uncertainty is different. In our model, we assume that there is no uncertainty. Uncertainty may thus not be an argument for discounting in our model. However, incorporating uncertainty, about e.g. γ, in the model, might very well justify discounting when sustainability is not feasible.

Figure 2 summarizes our main results for $\overline{R} \geq R^{\min}$:

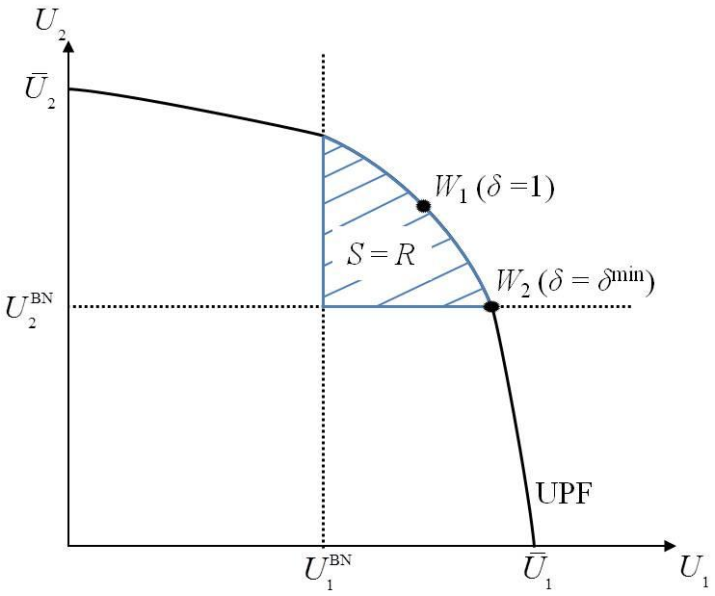

Figure 2: Illustration for $\overline{R} \geq R^{\min}$ of responsible (R, dashed area), sustainable (S, dashed area), Pareto-efficient (UPF) and discounted-utilitarian-welfare maximum (for example W_1 and W_2) allocations.

The utility possibility frontier (UPF) – the curve connecting $(0\,, \overline{U}_2)$ and $(\overline{U}_1, 0)$ – contains all Pareto-efficient allocations. On the UPF, we find the discounted-utilitarian-welfare maxima (for example W_1 and W_2). W_1 represents the special case of no discounting, that is $\delta = 1$. W_2 represents the special case of discounting utility of the future generation ($\delta = \delta^{\min} < 1$) such that $U_2 = U_2^{\mathrm{BN}}$. In general, all discounted-utilitarian-welfare maxima lie on the UPF, with their exact position determined by the discount rate. Discounting of future utility ($\delta < 1$) leads to a discounted-utilitarian-welfare maximum somewhere on the UPF between W_1 and $(\overline{U}_1, 0)$. If the discount rate decreases below $\delta^{\min}$, the discounted-utilitarian-welfare maximum yields

[11] See also Roemer (2011: 374): "And if [future] societies are indeed 'richer,' because of the technological progress that takes place […] and because we have saved the global commons for them, and it turns out that the optimal policy has their consuming more than we do, their average unit of consumption will not receive as much weight in the social-welfare function as our average unit […], which implements diminishing marginal utility. Why further discount their utility with positive discount rates?"

an allocation which is neither sustainable nor responsible.[12] Allocations that are sustainable (*S*) and responsible (*R*) are depicted by the dashed area which consists of the triangle delimited by $U_1 = U_1^{\mathrm{BN}}$, $U_2 = U_2^{\mathrm{BN}}$ and the UPF.

The picture changes fundamentally for $\overline{R} < R^{\min}$ as shown in Figure 3:

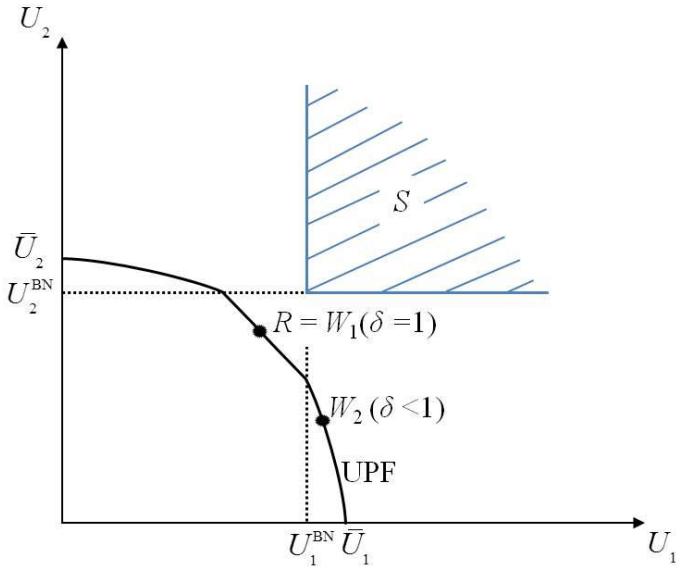

Figure 3: Illustration for $\overline{R} < R^{\min}$ of responsible (*R*), sustainable (*S*, dashed area), Pareto-efficient (*UPF*), and discounted-utilitarian-welfare maximum (for example W_1 and W_2) allocations.

Again, the UPF is connecting $(0\,, \overline{U}_2)$ and $(\overline{U}_1, 0)$ and contains all Pareto-efficient allocations. However, there is only one responsible allocation (*R*) which equals the discounted-utilitarian welfare maximum W_1 for $\delta = 1$. *R* and W_1 lie on the UPF but below satisfied basic needs levels. Since sustainability is not feasible, there are no sustainable allocations on or below the UPF, but all "sustainable" allocations (*S*, dahed area) would lie outside the UPF. We further see that for discounting the utilty of the future generation, $\delta < 1$, W_2 lies on the UPF somewhere between *R* (=W_1) and $(\overline{U}_1, 0)$, with the exact position again depending on the discount rate δ. Analogously, discounting of utility of the present generation, $\delta > 1$, leads to a discounted-utilitarian welfare maximum on the UPF somewhere between *R* and $(0\,, \overline{U}_2)$. As any $\delta \neq 1$ yields a discounted-utilitarian-welfare maximum below or above *R*, the discounted utilitarian welfare maximum cannot be responsible. But as shown in Figure 3, it may lead to an allocation in which one generation has its basic needs satisfied.

6 Conclusion

We have developed and formalized a utilitarian notion of responsibility which is inspired by Singer's (1972) principle and the Brundtland Commission's notion of sustainability (WCED

[12] The same reasoning applies for $\delta > 1$, i.e. discounting of utility of the present generation.

1987). Our results show that sustainabilty and responsibility for sustainability are equivalent if and only if sustainability is feasible. If it is not, there still exists a responsible allocation which is also Pareto-efficient. Further, the utilitarian welfare maximum without discounting always fulfills the criterion of responsibility. Discounting may be responsible to a certain extent if sustainability is feasible. If sustainability is not feasible, discounting is not responsible.

Our analysis demonstrates that reponsibility can be clearly and unambiguously conceptualized in economic models. Such a conception of responsibility is, albeit simple, neither trivial nor redundant, but adds specificity to the discussion about sustainability in two respects: (1) it clearly specifies how to act if sustainability is not feasible; (2) in any case, it specifies the balance between legitimate claims of present and future generations.

With these achievements, also the limits of our analysis are clear: we have built on a specific idea of sustainability and on a specific ethics, both of which focus on the satisfaction of basic needs (and, thus, go together very well). For other aspects of sustainability they are less well suited, and other notions of responsibility will be needed.

The conceptualization of responsibility with our approach lays out a broad basis for future research. In particular, the aspects of the possbility of compliance, namely the power and knowledge to comply, should be analyzed more deeply. With respect to the power to comply, there is the question of how the present generation can ensure that future generations are able to satisfy their basic needs given that the presently living persons have several options. With respect to knowledge, there immediately arises the problem of uncertainty, e.g. about technological progress, which affects the responsibility of the present generation. Uncertainty further raises the question of how much the present generation ought to invest in the reduction of uncertainty. We think that our approach can be helpful in adressing these issues.

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