A utilitarian notion of responsibility for sustainability

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Abstract: We develop and formalize a utilitarian notion of responsibility for sustainability inspired by Singer's (1972) principle of utilitarian ethics and the Brundtland Commission's notion of sustainability (WCED 1987). We relate this notion of responsibility to established criteria for the assessment of intertemporal choice: Pareto-efficiency, (discounted) utilitarian welfare maximization, and Brundtland-sustainability. Using a two-generations-resource-model, we find that sustainability and responsibility are equivalent if and only if sustainability is feasible. If it is not, there still exists a responsible allocation which is Pareto-efficient. The undiscounted utilitarian welfare maximum is responsible, while discounting is responsible if and only if sustainability is feasible and the discount factor is within certain limits.

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

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1 Introduction

Sustainability is a specific conception of intra- and intergenerational justice. As such it poses an imperative on presently living persons. More specifically, as defined by the Brundtland 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.[1]

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 set of feasible 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 and, thus, serves to assess and guide action (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 obli-

[1]Taking basic needs into account has been shown to be relevant, inter alia, in the growth, development and environmental economics literature (e.g. King and Rebelo 1993, Steger 2000, Pezzey and Anderies 2003, Kraay and Raddatz 2007, Ravn et al. 2008, Heal 2009, Garner 2010, Strulik 2010, Matsuo and Tomoda 2012).

gation 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. Responsibility thus provides a criterion for decision-making even if the aim of action (e.g. sustainability) is actually out of reach. Thereby, it adds to economic decision theory which traditionally assumes that the aim of action (e.g. utilitarian welfare maximization under some constraints) can always be reached. 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 of utilitarian ethics 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 actors 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 equiv-

alent 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 fulfils the criterion of responsibility. Discounting is responsible if and only if sustainability is feasible and the discount factor is within certain limits. 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 absolute normative conceptions such as sustainability or justice. In particular, we show how responsibility for some absolute normative objective – not just sustainability – provides an operational criterion for decision-making even if the aim of action, i.e. the normative objective, is actually out of reach, for example because it is not feasible.

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. All proofs are contained in the Appendix.

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 (Dobson 1998, Becker 2011). 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 anthropocentric and implies that only human beings deserve moral

attention. By "generation" it refers to all human beings living at the same time period.[2] 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 paper, we focus on the aspect of intergenerational justice and neglect the intragenerational dimension. However, our analysis can easily be extended to intragenerational justice.

The term "basic needs" requires further specification.[3] In the Brundtland-definition it is specified as "the essential needs of the world's poor, to which overriding priority should be given" (WCED 1987: 43). Despite extensive discussion, there is no consensus yet on the appropriate definition of basic needs (Sharif 1986, Max-Neef et al. 1991, Alkire 2002, Heal 2009, Rauschmayer et al. 2011, Baumgärtner et al. 2013). For instance, while some conceptualize the satisfaction of basic needs as a survival threshold in terms of water, air and food (e.g. Heal 2009: 279), others argue that it goes beyond mere biological subsistence and includes, inter alia, a minimum level of affection, understanding, participation and freedom (e.g. Max-Neef et al. 1991, Alkire 2002). Here, we follow the second strand. Basic needs, in this more encompassing interpretation, are to be satisfied through the consumption of private goods – such as adequate food, shelter and clothing – as well as services provided by and for the community at large – such as safe drinking water, sanitation, public transport, and health and educational facilities (ILO 1976: 33). If these goods and services are not available to a person at least to some critical amount, this person will suffer and may, in the extreme, even dy.

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 basic needs "are finite, few and classifiable; and [...] are the same in all cultures and in all historical periods" (Max–Neef et al. 1991: 18). In our analysis, we capture this core idea of basic needs by assuming that basic needs are objectively given and uniform across generations. These two assumptions focus our analysis on the implications of one core idea of "basic needs" for sustainability. They also ensure the applicability of Singer's principle in the context

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

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

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 fulfil 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 is crucial to choose actions that yield 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. This gap can be closed with the concept of responsibility.

Responsibility

Responsibility is a multifarious notion. In the philosophical discussion of responsibility, at least three different aspects of the notion have been distinguished (Baumgärtner et al. 2014: Section 3).

(1) The first meaning of responsibility is the ascription of some action and its consequences to the perpetrator ("Who did it?"). That is, one ascribes an action and its consequences to the perpetrator of that action, and the perpetrator allows for it to be thus ascribed (Baumgärtner et al. 2006: 227). This requires that the person has acted out of free will, that the consequent change in the state of the world is indeed a causal effect of the person's action, and that the person knew what she was doing. In this meaning, responsibility is purely descriptive and has no moral relevance by itself. It simply means that a person A is responsible for some action or consequence X if and only if A is the perpetrator of X.[4] This is a precondition of morality, as a person can only be morally praised or blamed for an action that can be ascribed to this person.

(2) "Responsibility" is often used as a synonym for "obligation" (Williams 2008:

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

458): "A is responsible for X if and only if A ought to see to it that X" (Goodin 1986: 50, similarly Bovens 1998: 25). In this second meaning, responsibility attains a moral significance when obligations exist which a person 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 holder has due to principles of justice. In view of Brundtland-sustainability, there exists a positive responsibility (in the sense of: obligation to fulfil 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; similarly Bovens 1998: 26, Baumgärtner et al. 2006: 233–236). In other words, responsibility is important whenever a person is facing a plurality of normative obligations, which may conflict with each other. This becomes relevant for sustainability as the Brundtland-notion of sustainability contains two, potentially conflicting 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: we consider the responsibility of a present actor for (the consequences of) her actions [aspect 1], as facing an obligation [aspect 2] to fulfil several legitimate and potentially conflicting claims [aspect 3] that arise from the multifarious imperative of sustainability. Thus, our notion of responsibility is not purely descriptive (first meaning) but is essentially normative, as it refers to an obligation (second meaning)

To further sharpen this notion of responsibility, we need to specify who bears responsibility for sustainability. In general, this could be every present actor, such as an individual person, a group of persons or a legally-defined private or public corporation (e.g. an association, firm or state). The minimum requirement for being responsible is to be a "person" in the following abstract sense.[5] A person is a distinct being with an

[5]From here on, we use the term "person" in this sense.

identity, such that it is distinguishable from other persons. A person is self-conscious, i.e. it is conscious of its own identity across space, time and different states of mind. A person has intellectual capacity, i.e. the ability to reason and reflect.[6]

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 and all future generations have legitimate claims due to Brundtland-sustainability.[7]

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 present 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.[8] Its rationale is that responsi-

[6]Locke (1959[1690]: 264) defines a person as "[a] thinking intelligent being that has reason and reflection and can consider itself as itself, the same thinking thing, in different times and places." 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.

[7]Note that the two groups of (1) the presently living generation, who holds legitimate claims to the satisfaction of their basic needs, and (2) the presently living persons who bear responsibility for sustainability, do not need to be identical. There may be members of the present generation who are not presently persons, and there may be present 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 a person-like entity because it has all the characteristics 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.

[8]The ought-implies-can criterion has its origin in Roman law ("nemo ultra posse obligatur" – no one is obligated beyond what (s)he is able to do; "impossibilium nulla est obligatio" – there is no obligation to the impossible). It has been introduced into modern ethical discussion by Thomas Hobbes (1973[1660]: Chap. XIV 25) and Immanuel Kant (1999[1781]: A807, B835; 1997[1788]: §6, II). Kant

bility presupposes the possibility of compliance. This implicates that a person has the power to comply, i.e. the person is not hindered by objective or subjective conditions. Power requires physical and mental abilities of the person as well as the availability and effectiveness of instruments or resources. The 'ought-implies-can' criterion, thus, means that a person is responsible only for what is in her power. In a situation in which she is powerless, she not only does not need to bear responsibility, but is, in fact, unable to do so. As an example (which is due to Singer 1972), imagine that a child is drowning in a lake while a person is standing nearby. 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. But without any such hindrance, the person would be responsible for saving the drowning child.

The second limit arises from the legitimate claims of the bearer of responsibility. Such legitimate claims are defined, for example, by a conception of justice within a community. 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. Hence, a presently acting person faces a conflict between the obligation for the satisfaction of basic needs of others and the obligation for the satisfaction of her own basic needs. But how exactly do the legitimate claims of a responsible person limit her responsibility for fulfilling the legitimate claims of others? An answer to this question is given by Singer's principle of utilitarian ethics.

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maintained that responsibility as an 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 1992[1793]: 62). Contemporary philosophers argue in a similar way that it would be "absurd to say that we ought to do what we cannot do" (Singer 1993[1980]: 242). Similarly: "Action-guiding principles must fit human capacities, or they become strange in a damaging way: pointless" (Griffin 1992: 123).

Singer's principle

The utilitarian ethicist Peter Singer starts with the normative assumption that suffering is something bad. Whether a person is suffering or not, according to Singer, can be objectively determined. Suffering may arise, for example, from lack of shelter or food or, more generally, from unsatisfied basic needs. 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[1690]) as defined above. Hence, all persons are responsible to prevent suffering of others, e.g. from unsatisfied basic needs, where this responsibility is limited in two regards.

The first limit of the responsibility to prevent suffering of others is the power to do so, in line with the ought-implies-can principle. The second limit, which is original to Singer's principle, is that a person who prevents suffering of others, in doing so, should not sacrifice "anything of comparable moral importance", i.e. should not make anyone else or herself suffering. This implies that the claims of a responsible person are legitimate in limiting her 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. Hence, the obligation to prevent or remedy the suffering of others is not limited by the acting person's claims to consumption goods unless the responsible person is also suffering from unsatisfied basic needs.

For this domain, where the acting person would have to give up something "of comparable moral importance", Singer (1972: 234) defines more specifically 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". 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

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

for the latter extends up to the point where positive and negative marginal effects of giving 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, which is also built on a lexicographic ordering: it only defines that basic needs should be satisfied, and not what ought to be done beyond that point.

To apply Singer's principle in the context of Brundtland-sustainability, we make the normative assumption that unsatisfied basic needs of present and future generations are something bad in the sense of Singer. 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 from unsatisfied basic needs 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 one's power to 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.

In the following, we formalize this utilitarian notion of responsibility for sustainability and explore its properties and implications in the framework of a simple model of intergenerational resource allocation.

3 Model

There are two non-overlapping generations $t = 1, 2$, each consisting of one representative person. 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 line with both Singer (1972) and Brundtland (WCED 1987), we assume that 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. 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 a person is 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 identical 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. The assumption of identical preferences below the basic needs level and potentially different preferences beyond that point is not only central in Singer's ethics and the Brundtland notion of sustainability but is also 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 of generations $t = 1, 2$ are given by (see Figure 1):

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

with $0 < \alpha_t \leq \alpha < 1$. Marginal utility from consumption is thus strictly larger if the basic needs are not met than if they are met. The utility level obtained from the basic-needs consumption level is $U^{\mathrm{BN}} := U_t(C^{\mathrm{BN}})$ and identical for both generations.

Consumption is being generated from the (consumptive) use of a resource stock

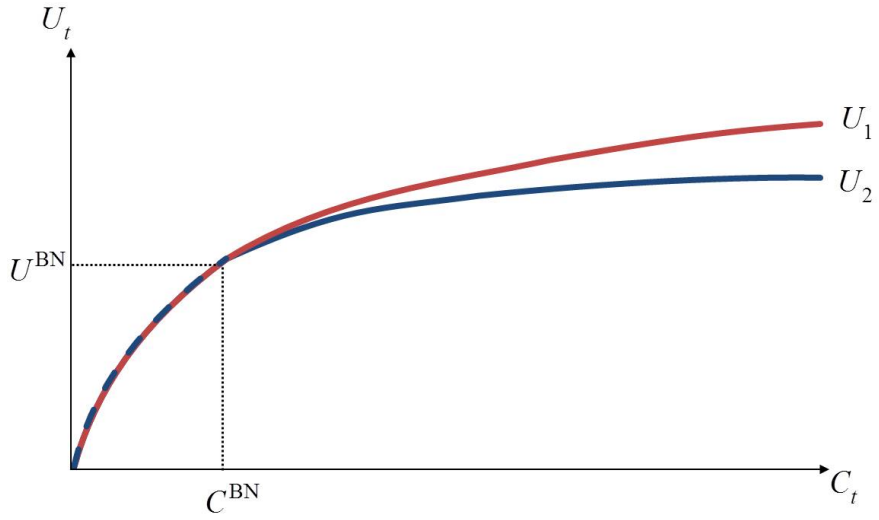

Figure 1: Utility functions of both generations.

$\bar{R} > 0$. This stock can be allocated between both generations such that each generation $t = 1, 2$ has an endowment R_t:

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

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

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

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

where $\gamma > 0$ is an exogenous factor which can be broadly interpreted: either as productivity change or 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 total resource endowment $R^{\min}$, which exactly allows both generations to satisfy their basic needs:

$$R^{\min} = \left(1 + \frac{1}{\gamma}\right) C^{\mathrm{BN}} \ . \tag{5}$$

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 charac-

terize each of these resource allocations with necessary and sufficient conditions. A resource allocation is *feasible* if the sum of the resource endowments is not larger than the total resource stock $\bar{R}$ (Condition 2).

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

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

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

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:

$$R_1 \geq C^{\mathrm{BN}} \quad \text{and} \quad R_2 \geq \frac{C^{\mathrm{BN}}}{\gamma} \ . \tag{7}$$

Proof: See Appendix A.1.

The conditions for sustainable allocations are intuitive: both generations need a minimal resource endowment, as characterized by Condition (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, Condition (7), together with feasibility Condition (2), shows that existence of sustainable allocations requires that $\bar{R} \geq R^{\min}$, where $R^{\min}$ is given by Equation (5).

We no formalize the notion of responsibility developed in Section 2 with respect to this notion of sustainability.

Definition 2 (Responsibility)

A feasible allocation (R_1, R_2) is called *responsible* if and only if it yields or solves

$$C_t(R_t) \geq C^{\mathrm{BN}} \quad \text{for} \quad t = 1, 2 \qquad \text{if } \bar{R} \geq R^{\min} \ , \tag{8}$$

$$\min_{R_1, R_2} \left[U^{\mathrm{BN}} - U_1\left(C_1(R_1)\right)\right] + \left[U^{\mathrm{BN}} - U_2\left(C_2(R_2)\right)\right] \quad \text{s.t.} \quad R_1 + R_2 \leq \bar{R} \quad \text{else} \ . \tag{9}$$

Our definition of responsibility is one of responsibility for Brundtland-sustainability in that it essentially aims at satisfying the basic needs of present and future generations. It captures Singer's principle as a twofold limit to the extent of responsibility. First, it distinguishes situations in which it is feasible to satisfy the basic needs of both generations (Equation 8), and situations in which this is not feasible (Equation 9). If it is feasible, Singer's principle demands that basic needs of both generations are satisfied Equation (8), as this prevents everyone from suffering without sacrificing "anything of comparable moral importance". Second, if the total resource endowment is too small for satisfying all basic needs, Singer's principle specifies that a responsible allocation is one in which suffering from unsatisfied basic needs is minimized (Equation 9). Obviously, the first-order condition for this objective requires to allocate resources "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" (see Equation (A.5) in the proof of Lemma 2 below). It is also apparent that in situations in which it is not feasible to satisfy all basic needs, Singer's notion of responsibility ("minimize suffering from unsatisfied basic needs") is equivalent to undiscounted-utilitarian-welfare maximization ("maximize the sum of utilities"), as optimization problem (9) is equivalent to

$$\max_{R_1, R_2} \ U_1\left(C_1(R_1)\right) + U_2\left(C_2(R_2)\right) \ \text{s.t.} \ R_1 + R_2 \leq \bar{R} \ . \tag{10}$$

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:

$$R_1 \geq C^{\mathrm{BN}} \text{ and } R_2 \geq \frac{C^{\mathrm{BN}}}{\gamma} \quad \text{for} \quad \bar{R} \geq R^{\min} \ , \tag{11}$$

$$R_1 = \gamma^{\frac{\alpha}{\alpha-1}} R_2 \text{ and } \bar{R} = R_1 + R_2 \quad \text{for} \quad \bar{R} < R^{\min} \ . \tag{12}$$

Proof: See Appendix A.2.

Lemma 2 shows that in the characterization of responsible allocations one needs to distinguish two cases: one in which attaining the underlying normative aim (here: sustainability) is feasible (Condition 11), and one in which it is not (Condition 12).

Next, we define Pareto-efficient allocations.

Definition 3 (Pareto-efficiency)
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 $U_t\left(C_t(R_t')\right) \geq U_t\left(C_t(R_t)\right)$ for all $t = 1, 2$ and $U_t\left(C_t(R_t')\right) > U_t\left(C_t(R_t)\right)$ 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:

$$\bar{R} = R_1 + R_2 \ . \tag{13}$$

Proof: See Appendix A.3.

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:

$$\max_{R_1, R_2} \ W = U_1\left(C_1(R_1)\right) + \delta U_2\left(C_2(R_2)\right) \ \text{ s.t. } \ R_1 + R_2 \leq \bar{R} \ . \tag{14}$$

In this definition, $\delta \geq 0$ is a utility 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 conditions:

$$\alpha_1 R_1^{\alpha_1 - 1} = \delta \alpha_2 \gamma^{\alpha_2} R_2^{\alpha_2 - 1} \quad \text{and} \quad \bar{R} = R_1 + R_2 \quad \text{for} \quad \bar{R} \geq R^{\min} \ , \tag{15}$$

$$R_1 = \delta^{\frac{1}{\alpha-1}} \gamma^{\frac{\alpha}{\alpha-1}} R_2 \quad \text{and} \quad \bar{R} = R_1 + R_2 \quad \text{for} \quad \bar{R} < R^{\min} \ . \tag{16}$$

Proof: See Appendix A.4.

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. Note that, if no discounting takes place ($\delta = 1$), Condition (16) is identical to Condition (12). That means, in a situation where it is not feasible to satisfy all basic needs ($\bar{R} < R^{\min}$), undiscounted-utilitarian-welfare maximization is responsible. The reason is that in such a situation, Singer's principle is equivalent to undiscounted-utilitarian-welfare maximization. Singer's principle differs from (un)discounted-welfare-maximization, though, in situations where it is feasible to satisfy all basic needs ($\bar{R} \geq R^{\min}$), so that Condition (15) differs from Condition (11) for all values of the discount factor δ.

Our analysis adds to the discussion about the ethical legitimacy of utility-discounting. Ever since Pigou (1920) it has been argued that while individual or societal impatience (pure time preference) may describe actual human behavior, it cannot be used normatively to justify discounting. Here, we qualify this argument, as we will show (in Proposition 4 below) that utility-discounting may, under certain conditions and to some extent, be ethically legitimate in view of responsibility for sustainability.

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 (Responsibility)
If $\bar{R} > R^{\min}$, there exist infinitely many responsible allocations, characterized by Con-

dition (11). If $\bar{R} \leq R^{\min}$, there exists a single responsible allocation, characterized by Condition (11) (for $\bar{R} = R^{\min}$) or Condition (12) (for $\bar{R} < R^{\min}$).

Proof: See Appendix A.5.

This means, that in any case there exists a responsible allocation. If sustainability is feasible and, in particular, resource endowment exceeds the minimum needed to satisfy all basic needs ($\bar{R} > R^{\min}$), 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 $\bar{R} < R^{\min}$ when sustainability is not feasible. At this allocation, $\bar{R}$ must be used completely ($\bar{R} = R_1 + R_2$) 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 $\bar{R} \geq R^{\min}$, each responsible allocation is also sustainable, and vice versa. In contrast, if $\bar{R} < R^{\min}$, the responsible allocation is not sustainable. Responsibility for sustainability is, hence, equivalent to sustainability if and only if sustainability is feasible.

Proof: See Appendix A.6.

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 $\bar{R} > R^{\min}$, some, but not all, of the (infinitely many) responsible allocations are also Pareto-efficient. These are characterized by

$$\bar{R} = R_1 + R_2 \quad \text{and} \quad R_1 \geq C^{\text{BN}} \quad \text{and} \quad R_2 \geq \frac{C^{\text{BN}}}{\gamma} \ . \tag{17}$$

If $\bar{R} \leq R^{\min}$, the (unique) responsible allocation is also Pareto-efficient. In both cases, not all Pareto-efficient allocations are responsible.

Proof: See Appendix A.7.

The intuition behind this result is as follows. Since the Brundtland notion of sustainability does not require Pareto-efficiency, the criterion of responsibility for sustainability does not require Pareto-efficiency either in situations where sustainable allocations are feasible and responsibility and sustainability are equivalent. The Brundtland notion of sustainability merely defines a minimum standard and allows for wasteful (i.e. Pareto-inefficient) allocations once the standard is achieved. On the other hand, if sustainability is not feasible, the criterion of responsibility requires non-wastefulness (i.e. 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 (15) or (16). If no discounting takes place, $\delta = 1$, the undiscounted-utilitarian-welfare-maximum allocation is responsible. If, in contrast, discounting takes place, $\delta \neq 1$, the following holds:

(i) For $\bar{R} > R^{\min}$, the discounted-utilitarian-welfare maximum is a responsible allocation if and only if

$$\delta^{\min} \leq \delta \leq \delta^{\max} \tag{18}$$

with

$$\delta^{\min} = \frac{\alpha_1}{\alpha_2}\gamma^{-1}\left(\bar{R} - \frac{C^{\mathrm{BN}}}{\gamma}\right)^{\alpha_1 - 1}, \tag{19}$$

$$\delta^{\max} = \frac{\alpha_1}{\alpha_2}\gamma^{-\alpha_2}\left(\bar{R} - C^{\mathrm{BN}}\right)^{1-\alpha_2}. \tag{20}$$

(ii) For $\bar{R} \leq R^{\min}$, the discounted-utilitarian-welfare maximum is not a responsible allocation.

Proof: See Appendix A.8.

Let us first discuss the case without discounting, that is $\delta = 1$. If the resource stock is large enough ($\bar{R} \geq R^{\min}$) 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 (Equation 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. $\bar{R} < R^{\min}$), 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 the resource endowment exceeds the minimum necessary to satisfy all basic needs and the discount rate is within the range specified by Condition (18). 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 (18) 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 (18) has the following intuitive properties. Large technological progress (γ) allows for larger discounting of future utility to be responsible. A large resource stock ($\bar{R}$) 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 that no sustainable allocation exists ($\bar{R} < R^{\min}$), discounting is not responsible. Any unequal valuation of utility between generations will not minimize suffering and, therefore, cannot be responsible.

Figure 2 summarizes our main results for $\bar{R} \geq R^{\min}$. The utility possibility frontier

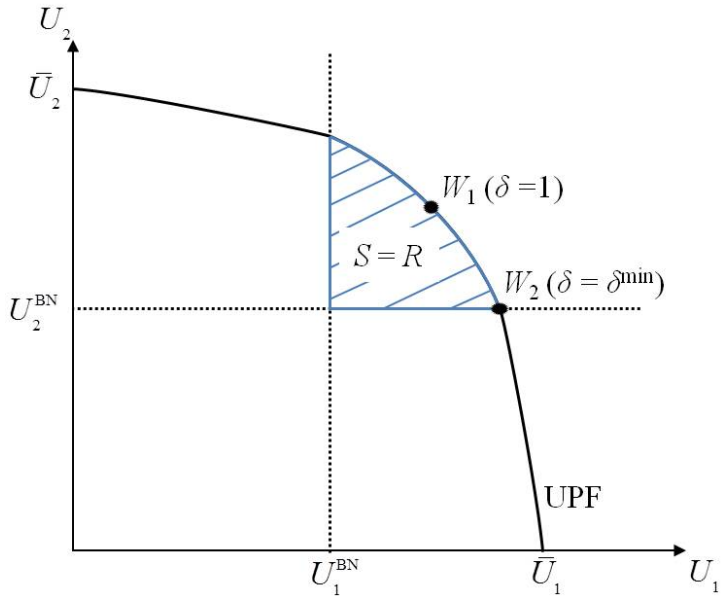

Figure 2: Illustration for $\bar{R} > R^{\min}$ of responsible (R, dashed area), sustainable (S, dashed area), Pareto-efficient (UPF) and sicounted-utilitarian-welfare maximum (for example W_1 and W_2) allocations.

(UPF) – the curve connecting $(0, \bar{U}_2)$ and $(\bar{U}_1, 0)$ – 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 $(\bar{U}_1, 0)$. If the discount rate decreases below $\delta^{\min}$, the discounted-utilitarian-welfare maximum yields an allocation which is neither sustainable nor responsible.[10] 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 $\bar{R} < R^{\min}$ as shown in Figure 3. Again, the

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

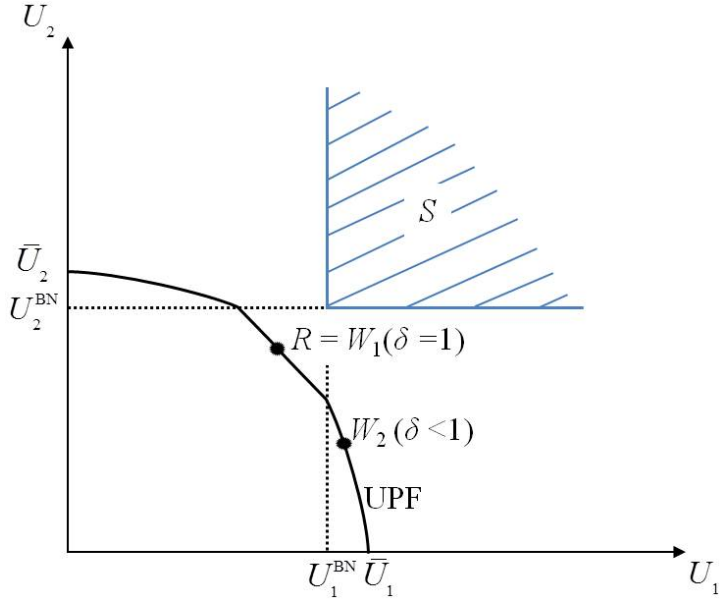

Figure 3: Illustration for $\bar{R} < R^{\min}$ of responsible (R), sustainable (S, dashed area), Pareto-efficient (UPF), and discounted-utilitarian-welfare maximum (for example W_1 and W_2) allocations.

UPF is connecting $(0, \bar{U}_2)$ and $(\bar{U}_1, 0)$ 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, dashed area) would lie outside the UPF. We further see that for discounting the utility of the future generation, $\delta < 1$, W_2 lies on the UPF somewhere between $R(= W_1)$ and $(U_1, 0)$, 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 $(0, \bar{U}_2)$. 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 of utilitarian ethics and the Brundtland Commission's notion of sustainability (WCED 1987). 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 fulfils the criterion of responsibility. Discounting of future utility is responsible if and only if sustainability is feasible and the discount factor is within certain limits. If sustainability is not feasible, discounting is not responsible.

Our analysis demonstrates that responsibility 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, fit together very well). For other aspects of sustainability they are less well suited, and other notions of responsibility will be needed. More specifically, our results are essentially driven by the assumptions of the basic needs concept in Singer's ethics and in the Brundtland notion of sustainability: there exists a basic needs threshold which is identical for all human beings and below which preferences are identical

The conceptualization of responsibility with our approach lays out a broad basis for future research. In particular, the aspects of the possibility 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 addressing these issues.

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Appendix

A.1 Proof of Lemma 1

Condition (7) follows from the defining Condition (6) and production functions (3), (4).

A.2 Proof of Lemma 2

Case I: $\bar{R} \geq R^{\min}$

Condition (11) follows from the defining Condition (8) and production functions (3), (4).

Case II: $\bar{R} < R^{\min}$

The defining problem (9) is obviously equivalent to problem (10). The Lagrangian for this problem is

$$L(R_1, R_2; \lambda) = U_1\left(C_1(R_1)\right) + U_2\left(C_2(R_2)\right) + \lambda\left[\bar{R} - R_1 - R_2\right] \ , \tag{A.1}$$

and the first-order conditions are

$$\frac{\partial L}{\partial R_1} = U_1'(C_1(R_1))\, C_1'(R_1) - \lambda = 0 \ , \tag{A.2}$$

$$\frac{\partial L}{\partial R_2} = U_2'(C_2(R_2))\, C_2'(R_2) - \lambda = 0 \ , \tag{A.3}$$

$$\frac{\partial L}{\partial \lambda} = \bar{R} - R_1 - R_2 = 0 \ , \tag{A.4}$$

where a prime denotes the first derivative of a function with respect to its (sole) argument. Because $U_t(C_t)$ is strictly concave (according to Equation 1) and $C_t(R_t)$ is linear (according to Equations 3, 4) for both $t = 1, 2$, the Lagrangian is strictly concave and these first-order conditions are necessary and sufficient.

Eliminating λ from Conditions (A.2) and (A.3) yields

$$U_1'(C_1(R_1))\, C_1'(R_1) = U_2'(C_2(R_2))\, C_2'(R_2) \ , \tag{A.5}$$

which states that the responsible resource allocation if basic needs cannot be met for all is such that resources are allocated "up 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).

With utility function (1), and for the case where both generations suffer from unsatisfied basic needs ($C_t < C^{\mathrm{BN}}$), one has for both $t = 1, 2$:

$$U_t'(C_t) = \alpha C_1^{\alpha-1} \ . \tag{A.6}$$

With production functions (3), (4), one has

$$C_1'(R_1) = 1 \tag{A.7}$$

$$C_2'(R_2) = \gamma \ . \tag{A.8}$$

Employing (A.6), (3), (4), (A.7) and (A.8) in Condition (A.5) yields:

$$\alpha R_1^{\alpha-1} = \alpha\, (\gamma R_2)^{\alpha-1}\, \gamma \tag{A.9}$$

which can be rearranged into result (12).

A.3 Proof of Lemma 3

Since there is only one resource, which can only be transformed into one good, there are no externalities, and all production and utility functions are strictly monotonic, all allocations which use the entire resource stock $\bar{R}$ must be Pareto-efficient.

A.4 Proof of Lemma 4

The Lagrangian for the defining problem (14) is

$$L(R_1, R_2; \lambda) = U_1\left(C_1(R_1)\right) + \delta\, U_2\left(C_2(R_2)\right) + \lambda\left[\bar{R} - R_1 - R_2\right] \ , \tag{A.10}$$

and the first-order conditions are

$$\frac{\partial L}{\partial R_1} = U_1'(C_1(R_1))\, C_1'(R_1) - \lambda = 0 \ , \tag{A.11}$$

$$\frac{\partial L}{\partial R_2} = \delta\, U_2'(C_2(R_2))\, C_2'(R_2) - \lambda = 0 \ , \tag{A.12}$$

$$\frac{\partial L}{\partial \lambda} = \bar{R} - R_1 - R_2 = 0 \ , \tag{A.13}$$

where a prime denotes the first derivative of a function with respect to its (sole) argument. Because $U_t(C_t)$ is strictly concave (according to Equation 1) and $C_t(R_t)$ is linear (according to Equations 3, 4) for both $t = 1, 2$, the Lagrangian is strictly concave and these first-order conditions are necessary and sufficient.

Eliminating λ from Conditions (A.11) and (A.12) yields

$$U_1'(C_1(R_1))\, C_1'(R_1) = \delta\, U_2'(C_2(R_2))\, C_2'(R_2) \ . \tag{A.14}$$

With production functions (3), (4), one has

$$C_1'(R_1) = 1 \tag{A.15}$$

$$C_2'(R_2) = \gamma \ , \tag{A.16}$$

so that Condition (A.14) becomes

$$U_1'(C_1(R_1)) = \delta\, \gamma\, U_2'(C_2(R_2)) \ . \tag{A.17}$$

For the solution of this equation, several cases need to be distinguished.

Case I: $C_1, C_2 > C^{\mathrm{BN}}$

With utility function (1) one has:

$$U_1'(C_1) = \alpha_1 C_1^{\alpha_1 - 1} , \tag{A.18}$$

$$U_2'(C_2)) = \alpha_2 C_2^{\alpha_2 - 1} . \tag{A.19}$$

Employing (A.18), (A.19), (3), (4), in Condition (A.17) yields:

$$\alpha_1 R_1^{\alpha_1 - 1} = \delta \alpha_2 \left(\gamma R_2\right)^{\alpha_2 - 1} \gamma \tag{A.20}$$

which can be rearranged into result (15).

Case II: $C_1, C_2 \leq C^{\mathrm{BN}}$

With utility function (1) one has for both $t = 1, 2$:

$$U_t'(C_t) = \alpha C_1^{\alpha - 1} . \tag{A.21}$$

Employing (A.21), (3), (4) in Condition (A.17) yields:

$$\alpha R_1^{\alpha - 1} = \delta \alpha \left(\gamma R_2\right)^{\alpha - 1} \gamma \tag{A.22}$$

which can be rearranged into result (16).

A.5 Proof of Proposition 1

Equation (11), together with Equations (2) and (5), shows that there are infinitely many responsible allocations if and only if $\bar{R} > R^{\min}$, and that there is a single responsible allocation if $\bar{R} = R^{\min}$. Equation (12) shows that there exists a single responsible allocation if $\bar{R} < R^{\min}$.

A.6 Proof of Proposition 2

Comparison of Conditions (7) and (11) shows that all allocations satisfying Condition (11) must also satisfy Condition (7), and vice versa. Comparison of Conditions (7) and (12), and using Equation (5), shows that an allocation satisfying Condition (12) cannot satisfy Condition (7).

A.7 Proof of Proposition 3

Comparison of Conditions (13) and (11) shows that some but not all allocations satisfying Condition (11) also satisfy Condition (13), e.g. $R_1 = C^{\mathrm{BN}}$ and $R_2 = C^{\mathrm{BN}}/\gamma$ for $\bar{R} > R^{\min}$ satisfies Condition (11) but not Condition (13), while all $R_1 = C^{\mathrm{BN}} + \epsilon$ and $R_2 = C^{\mathrm{BN}}/\gamma$ for $\bar{R} = R^{\min} + \epsilon$ with $\epsilon \geq 0$ satisfy Condition (11) and (13).Condition (17) follows straightforwardly from Conditions (13) and (11).

Comparison of Conditions (13) and (12) shows that an allocation satisfying Condition (12) also satisfies Condition (13), as Condition (13) is part of Condition (12). But not all allocations satisfying Condition (13) satisfy Condition (12), e.g. $R_1 = C^{\mathrm{BN}} - \epsilon$ and $R_2 = C^{\mathrm{BN}}/\gamma$ for $\bar{R} = R^{\min} - \epsilon$ with $\epsilon \geq 0$.

A.8 Proof of Proposition 4

For $\delta = 1$, comparison of Conditions (16) and (12) shows that all allocations satisfying Condition (16) must also satisfy Condition (12). The same holds for Conditions (15) and (11), since $\alpha_t < \alpha$ for all $t = 1, 2$. For $\delta \neq 1$, using $R_2 \geq C^{\mathrm{BN}}/\gamma$ from Condition (11) and $R_1 \geq C^{\mathrm{BN}}$ in Condition (15) yields Condition (18). Comparison of Conditions (16) and (12) shows that an allocation satisfying Condition (16) cannot satisfy Condition (12).