Should we discount future generations' welfare?
A survey on the "pure" discount rate debate.

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Abstract

In *A Mathematical Theory of Saving* (1928), Frank Ramsey not only laid the foundations of the fruitful optimal growth literature, but also launched a major moral debate: should we discount future generations' well-being? While Ramsey regarded such "pure" discounting as "ethically indefensible", several philosophers and economists have developed arguments justifying the "pure" discounting practice since the early 1960s. This essay consists of a survey of those arguments. After a brief examination of the – often implicit – treatment of future generations' welfare by utilitarian thinkers before Ramsey's view was expressed, later arguments of various kinds are analysed. It is argued that, under the assumption of perfect certainty regarding future human life, the "pure" discounting practice seems ethically untenable. However, once we account for the uncertainty regarding future generations' existence, "pure" discounting seems more acceptable, even if strong criticisms still remain, especially regarding the adequateness of the expected utility theory in such a normative context.

1: Introduction

In one of his memorable contributions to economics, *A Mathematical Theory of Saving* (1928), Frank Ramsey not only laid the foundations of the fruitful optimal growth literature, but also launched a major moral debate: the "pure" discount rate debate. That debate can be summarized in one question: should we discount future generations' well-being? In other words, should we assign lower weights to future people's well-being in our determination of the optimal intergenerational policy?[1] In this essay, I shall largely confine myself to the study of that issue within utilitarianism[2]. However, it should be stressed that the issue of the relative weights to be given to each generation is not specific to utilitarianism, but rather is present, under different forms, in any theory of intergenerational justice.

More specifically, this essay is concerned with "intergenerational" utilitarianism: no attention is paid to individuals' own discount rates, nor to individuals' levels of utility: this essay simply focuses on the weights to be assigned to the well-being of future "generations", a generation being defined here as "a group of people living at the same time"[3]. The issue at stake here is the validity of the use of a non-zero "pure" discount rate in an (intergenerational) social welfare function (SWF) of the "pragmatical" kind, that is, according to Kolm (1969), a function describing the social or ethical preferences of a rational individual (in contrast with a "categorical" social welfare function, describing the society's preferences).

Regarding the "pure" discount rate issue, Ramsey's well-known ethical position was that such a practice "is ethically indefensible and arises merely from the weakness of the imagination"[4]. Such an impartial position, under the certainty assumption, was also taken by Harrod (1948), rejecting "pure" discounting as being "a polite expression for rapacity and the conquest of reason by passion"[5]. However, not all thinkers have adopted the same views, so that the "pure" discount rate debate has been flourishing since the early 1960s, time at which Ramsey's contribution served as a starting point for a whole research program in economics. Since that time, philosophers and economists have developed numerous arguments, either justifying the "pure" discounting practice, or, on the contrary, proscribing its use. This essay consists of a survey of some of those arguments. This fascinating literature being very large, this survey cannot have any pretension to exhaustiveness. Moreover, it should be stressed that this survey will be concerned only with arguments justifying a zero or a positive discount rate, without considering any quantitative aspect of that ethical issue.

The rest of this essay is organized as follows. Before analysing the arguments developed after Ramsey's work, it might be interesting to examine briefly the – more or less implicit – treatment of future generations' welfare by some "fathers" of utilitarianism: Bentham (1789) and Sidgwick (1874) (section 2). Roughly speaking, those contributions might be interpreted as suggesting a different treatment of future generations' utilities according to the degree of certainty associated with them. Therefore the next two sections respect that distinction: while section 3 deals with arguments for and against "pure" discounting under the assumption of complete certainty, section 4 is concerned with the potential justification of "pure"

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[1] That debate on the discounting of future generations' well-being, known as the "pure" discount rate debate, should not be confused with another the widely used discounting of commodities. On the distinction between those two concepts, see Broome (1992, 1999).

[2] According to Sen (1984), utilitarianism is the combination of three elements: welfarism, consequentialism and sum-ranking. Moreover, it should be stressed, as in Sen (1984), that the concept of "utility" might take three different senses: pleasure-happiness, desire-fulfilment, and the numerical representation of preferences. Most of the arguments developed here use the first or the second meaning of "utility".

[3] On the issue of the definition of "generation", see Laslett (1971).

[4] Ramsey (1928), p. 543. However, Ramsey used a "pure" discount rate in some parts of his paper.

[5] Harrod (1948), p. 40, quoted in Koopmans (1967), p. 1.

discounting under uncertainty about future generations' existence. Conclusions are drawn in section 5.

2: Bentham (1789) and Sidgwick (1874) on future generations' welfare

Although it is generally acknowledged that Ramsey is the thinker who explicitly launched the "pure" discounting debate, some furtive considerations regarding the treatment of future generations' utilities might be found in earlier utilitarian writings. Utilitarian writings being numerous, I shall confine myself here with famous writings by two of his "fathers", namely Bentham and Sidgwick, in order to try to find considerations on the treatment of future generations.

For that purpose, a natural "candidate" seems to be Bentham's *Introduction to the Principles of Morals and Legislation* (1789). Indeed, Bentham wrote[6]:

> "To a number of persons, with reference to each of whom the value of a pleasure or a pain is considered, it will be greater or less, according to seven circumstances […]: (1) its *intensity*; (2) its *duration*; (3) its *certainty* or *uncertainty*; (4) its *propinquity* or *remoteness*; (5) Its *fecundity*; (6) its *purity*; (7) its *extent*; that is, the number of persons to whom it *extends*; or […] who are affected by it."

As Williams (1978) underlined, Bentham's assumptions (3) and (4) may apparently involve some "pure" discounting, because of respectively "uncertainty" and "remoteness". However, one could interpret those assumptions in different ways. For instance, assumption (4), according to Birnbacher (1994), might take different meanings. Indeed, one could interpret (4) as justifying the use of a "pure" discount rate to lower the value of future pleasures, only because of their futurity[7]. On the other hand, one could interpret (4) as simply stating that people's current pleasure is lower when the future source of their current anticipated pleasure is more distant in time. Under that interpretation, supported by Birnbacher, no justification to discounting would be justified because of "remoteness": Bentham would have simply described a psychological fact regarding people's feelings. That interpretation is widely supported, for instance by Jevons (1871)[8]:

> "It is certain that a very large part of what we experience in life depends not on the actual circumstances of the moment so much as on the anticipation of future events. […] The intensity of present anticipated feeling must, to use a mathematical expression, be *some function of the future actual feeling and of the intervening time*, and it must increase as we approach the moment of realization."

Therefore the quoted passage in Bentham (1789) might not justify "pure" discounting because of the futurity of pleasures. The same interpretation could also be applied to assumption (3): Bentham might have simply stated some psychological facts regarding people's feelings.

However, the treatment of future generations' utilities has been more explicit in Sidgwick's *The Methods of Ethics* (1874), whose definition of utilitarianism as "universalistic hedonism" clearly implies that a utilitarian should treat people's utilities independently of the time at which they occur. Utilitarianism's aim is the "greatest happiness of the greatest number", and, according to Sidgwick, that number should not exclude distant generations. Sidgwick's impartial view was expressed as follows (1874)[9]:

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[6] Bentham (1789), republished in Mill, *Utilitarianism* (edited by Warnock), (1962), p. 65 (italics of the author).
[7] Birnbacher (1994) noticed that this interpretation was shared by Myrdal's (1962), p. 221.
[8] Jevons (1871), p. 98 (italics of the author).
[9] Sidgwick (1874), p. 414.

"It seems, however, clear that the time at which a man exists cannot affect the value of his happiness from a universal point of view; and that the interests of posterity must concern a Utilitarian as much as those of his contemporaries, except in so far as the effect of his actions on posterity – and even the existence of human beings to be affected – must necessarily be more uncertain".

Therefore, it seems that, according to Sidgwick, no discounting should be applied under the certainty assumption: the same weights should be given to each generation's utilities. Only the uncertainty regarding "the effects on posterity" might justify lower weights to be assigned to future people's welfare.

To summarize, while some thinkers might refer to Bentham and Sidgwick's writings to justify "pure" discounting, such a strategy might fail, at least to some extent: one could interpret Bentham as simply stating psychological facts, while Sidgwick's universalistic hedonism would only justify "pure" discounting on the grounds of the uncertainty of our effects on future generations' welfare, but not because of the mere time distance: if there is a complete certainty, no discounting should be applied.

3: Some arguments for and against a zero "pure" discount rate under certainty

A popular argument in favour of a positive "pure" discount rate is the argument from democracy: as individuals care less about the future, then a democratic public agent should take that characteristic of people's preferences into account, and hence should apply a positive discount rate to future generations' welfare. However, that argument does not stand up to Sen (1961) and Parfit (1984) criticisms. Even if individuals exhibit some pure time preference, this does not constitute a sufficient reason for pragmatical social welfare functions to exhibit the same characteristic[10]. Sen (1961) noticed that if democracy means that all the people affected by a decision must themselves make the decision, then there can be no democratic solution to intergenerational problems, the future generations being not born yet. Parfit (1984) rejected the argument from democracy, arguing that two questions are involved: (1), as a community, is it "moral" to use a social discount rate; and (2), if there is a majority of "yes" to question (1), should a government override the majority view? According to Parfit, a democrat's commitment to democracy gives him the answer to (2), but provides him an answer to question (1) only if he assumes that what the majority wants, or believes to be right, must be right. Parfit argues that no reasonable democrat assumes that.

A related argument in favour of pure discounting was expressed by Eckstein (1957), who argued that pragmatical social welfare functions based on "consumers' sovereignty" should accept people's tastes, including their intertemporal preferences. But Sen (1961) argued, rightly in my view, that, if a "consumers' sovereignty" principle must hold, then all the consumers should be considered, even the future (not born yet) consumers.

Therefore neither the "democracy" nor the "consumers sovereignty" arguments seem sufficient to dispense us from moral obligations with respect to future people. But what should be our responsibilities towards future generations, and thus what are the "sacrifices" we should do for them? According to Kavka (1978), solving that issue requires to deal with two distinct moral problems: firstly, the "Friends and Strangers Problem" (the extent of our moral obligations with respect to strangers), and, secondly, the "Futurity Problem" (the extent to which we should assign the same weight to future and present persons in our moral decisions, independently on considerations based on particular relationships such as friendship or love). Kavka focused on the second problem only, and wanted to show that if we

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[10] Democracy would be a sufficient reason to incorporate a positive pure discount rate in a "categorical" SWF, describing the society's preferences. That view was expressed by Marglin (1963).

admit that we have some obligations regarding needy present persons, then we must also have obligations towards future persons. Kavka derived that statement by attacking three reasons for giving future people lower weights: the temporal location of future people, our ignorance of them, and the contingency of their lives. According to Kavka, the location of people in the future does not affect at all our obligations towards them. Kavka argued that there are reasons for favouring present people's desires over dead people's desires (past generations). Indeed, we probably cannot affect dead people's happiness, and, moreover, dead people cannot experience the satisfaction of the fulfilment of their desires. However, as Kavka rightly underlined, those reasons can be used when we consider our obligations towards people distant in the past, but definitely not towards people distant in the future. Regarding our ignorance of future people's tastes and desires, Kavka argued, rightly in my view[11]:

> "For we do know with a high degree of certainty the basic biological and economic needs of future generations – enough food to eat, air to breathe, space to move in, and fuel to run machines. The satisfaction of these needs will surely be a prerequisite of the satisfaction of most of the other desires and interests of future people, whatever they may be."

Hence one cannot use the ignorance of future people's tastes to avoid obligations towards them. Kavka also attacked Golding's (1972) argument, according to which one should not have obligations towards distant future people, because distant people will probably not share our conception of a good life, so that it is difficult to know what to desire for them. Hence, according to Golding, distant people should not be regarded as belonging to our moral community, and we should not have moral obligations towards them. Against that argument, Kavka argued that there exists no degree of membership in the human moral community, and that membership in the human moral community does not depend on possessing some conception of what a good life is. Given that this section deals with arguments under certainty, I leave Kavka's treatment of the last reason, that is, the fact that future people might not exist, for section 4. But it should be stressed, at this stage, that Kavka's view leads to a rejection of "pure" discounting under certainty.

Kavka (1978) was only concerned with the "Futuriry Problem", but not with the "Strangers Problem", so that one could argue that Kavka might well be right, but that we do not have moral obligations with respect to "strangers". Hence, another argument for pure discounting is the one of the special relations. Indeed, it is often argued that we should assign greater "weights" to people nearer to us, compared with "strangers". In the intergenerational framework, it means that we should give more weight to our children than to our grandchildren, etc. However, Parfit (1984) provided two restrictions to that argument suggesting a new kind of discounting: discounting not for time, but for degrees of kinship. Firstly, according to Parfit, giving some priority to the nearer generations does not imply that we should give no weight to generations very "distant" in the future: this is unfortunately what a positive discount rate implies. Secondly, Parfit argued that such a discount rate should not be applied to all kinds of effects (grave harms example). As Broome (1992), I am convinced by Parfit's arguments. Special responsibilities towards nearer people cannot justify the ignorance of very "distant" generations, and cannot justify absolute priority regarding any imaginable decision.

However, Koopmans (1967a, 1967b) underlined that several growth models[12] had no optimal consumption path if the discount rate was below some level determined by the rates of population growth and of technological progress: in that case, further postponements of current consumption would always improve intergenerational welfare, according to Von

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[11] Kavka (1978), p. 189.
[12] For instance, the growth models by Cass (1965) and Mirrlees (1967).

Weizsäcker's (1965) overtaking criterion[13]. That argument might be regarded as a defence of discounting on the grounds of "mathematical convenience". However, I think that what Koopmans emphasized is rather an incapacity of social welfare functions without discount rate to select an optimal path under some circumstances. The incompleteness of the resulting rankings might be problematic, especially if one considers that it is the task of a SWF to provide complete orderings of paths. Therefore, the power of Koopmans's argument depends clearly on what one expects from a social evaluation criterion. Koopmans clearly expressed his view[14]:

> "The moral of our story is that ethical principles, in the subject-matter in hand, need mathematical screening to determine whether in given circumstances they are capable of implementation".

In my opinion, rather than being a narrow mathematical argument, Koopmans's view raises the difficult question of the status of ethical knowledge. Such a complex issue cannot be explored here. The only things that could be said to relativize Koopmans's argument are the following. Firstly, completeness of the resulting orderings might not be considered as an indispensable feature of social welfare criteria[15]. Secondly, even if completeness is highly valued, the introduction of a positive discount rate does not necessary lead to a complete ordering of paths. In other words, the introduction of a positive discount rate within a SWF is not always sufficient to provide complete orderings[16]. Thirdly, one should not overemphasize that argument: the incapacity to select optimal paths concerns particular cases only.

Moreover, Dasgupta and Heal (1979) underlined that, in the presence of a fixed stock of exhaustible resources ("cake-eating economy"), the solution under a zero discount rate, being that no generation consumes anything from the stock, is sub-optimal[17]. Indeed, under a zero discount rate, each generation would always sacrifice more of its consumption to improve intergenerational welfare, infinitely, so that the only feasible consumption path (with equal consumption for all generations) is the path where each generation consumes nothing, that is, it is the path where no generation would ever benefit from the stock of exhaustible resources. However, that solution path (under a zero discount rate) is overtaken, according to Von Weizsäcker's criterion, by any solution including a strictly positive discount rate, which would allow a limited number of generations to benefit from the exhaustible resources. This might constitute a good argument against zero discounting. However, as Broome (1992) noticed, no discount rate could be the right one, because it would always be better to halve it, under the assumption of decreasing marginal benefits from depletion. Hence SWFs with positive discount rates, although they provide a better solution, also fail to select an optimum path to that optimisation problem for which no optimum exists, and that is "unsolvable"[18]. Therefore Dasgupta and Heal's argument against zero discounting under certainty does not seem to be completely convincing. Moreover, it focuses on a particular case (exhaustible resources).

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[13] According to Von Weizsäcker (1965, p. 85), a feasible consumption program $c_1(t)$ is better than another feasible consumption program $c_2(t)$, if there exists some time T_0 such that for all $T \geq T_0$,

$$\int_0^T \left[u\big(c_1(t),t\big) - u\big(c_2(t),t\big) \right] dt > 0$$

[14] Koopmans (1967a), p. 41.

[15] Indeed, one could consider, as Sen (1984, p. 200), that the "completeness requirement is neither methodologically sensible nor substantially plausible".

[16] This point was made by Professor Mirrlees.

[17] However, as Professor Michel pointed out to me, there exists no optimal solution to this problem, any solution being sub-optimal (see *infra*).

[18] On the theoretical distinction between an optimization problem "without optimum" and an "unsolvable" optimisation problem, see Von Weizsäcker (1965).

Several axiomatic arguments were also invoked in the "pure" discount rate debate. A first axiomatic argument for "pure" discounting was developed by Koopmans (1960). According to Koopmans (1960), simple postulates on an ordinal utility function[19] of infinite consumption programs (continuity, sensitivity[20], stationarity[21], the absence of intertemporal complementarity[22], and the existence of a best and a worst program) logically imply "impatience"[23] for certain broad classes of programmes[24]. Such an implied "impatience", corresponding to a preference for advanced timing of satisfaction, might support the use of a "pure" discount rate. However, as Loewenstein and Prelec (1992) underlined, there exists some empirical evidence against the stationarity axiom. Indeed, Thaler (1981) showed that the ranking between two alternatives may change over time: for instance, a person might prefer one apple today to two apples tomorrow, but two apples in 51 days to one apple in 50 days. However, Koopmans allowed for some flexibility in the interpretation of his postulated axioms: those might be regarded, for instance, as a "guide" for rational choices in a planned economy. In that case, empirical arguments against his axioms would be irrelevant.

Alternatively, Diamond (1965) showed the "eventual impatience" implications of a slightly different set of axioms on preference orderings over an infinite future (in a one good framework)[25]. Here again, the implied "eventual impatience" might be regarded as a support for a positive discount rate. But the consequences of that axiomatic demonstration on the "pure" discount rate debate appears more clearly, when Yaari (in Diamond, 1965), showed the incompatibility between a sensitivity axiom[26] and an axiom requiring an equal treatment for all generations[27]. Dasgupta and Heal (1979) reformulated Yaari's result as the impossibility to have a SWF being continuous, Paretian, and treating all generations equally. How could one avoid that incompatibility? As Dasgupta and Heal (1979) underlined, one way to escape that incompatibility could be to assume that it is not necessary that all utility sequences are comparable. However, if one wants to keep a SWF, then that incompatibility can only be avoided by dropping one of the three axioms. Should we drop the intergenerational equity axiom, and thus permit some "pure" discounting? Broome (1992) argued that we should not. According to Broome, the incompatibility could be solved by replacing Diamond's requirement of continuity, which is inconsistent with the impartiality requirement, by a weaker continuity condition. Here again, the underlying issue is which properties one expects from a social evaluation criterion.

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[19] A function that retains its meaning under a monotonic (increasing) transformation.

[20] Sensitivity of the utility function requires that utility can be changed by changing the consumption vector in some designated period.

[21] Stationarity requires here that the preference ordering over programs remains the same if one advances the timing of each future consumption vector by one period.

[22] This requires that a particular commodity bundle consumed in the first period has no effect on the preference between alternative sequences of bundles in the future.

[23] "Impatience" was defined by Koopmans as follows (1960, p. 296): "If $u_1 > u_2$, the [impatience] condition says that interchange of the first-period consumption vector x_1 with the *less desirable* second-period vector x_2 *decreases* aggregate utility." Impatience, being a property of the underlying preference ordering, is thus also a property of any utility function representing that preference ordering.

[24] That result was extended and generalized in Koopmans, Diamond and Williamson (1964).

[25] Diamond (1965) defined the concept of "eventual impatience" as the property that "reversing the timing of the first and the *t*th period utility levels raises the utility of the entire stream if it places the larger one period level in the first period" (Diamond, 1965, p. 173). Thus this is impatience for the first over the *t*th period for all t sufficiently far in the future.

[26] That axiom states that "a utility stream that has at least as high one period utility levels in all periods as a second stream and a higher level in at least one period, is preferred to the second" (Diamond, 1965, p. 173).

[27] That axiom requires that $U \sim U^t$ for all U in X and all t=1,2,… (where U^t corresponds to U except that the tth utility levels and the first one have been interchanged, and where X corresponds to the set of all utility streams).

Furthermore, Koopmans (1972), based on Koopmans (1960) and (1966)[28], logically derived the existence of an impatience inequality from axioms on preference orderings (continuity, sensitivity, independence, stationarity and monotonicity). As Dasgupta and Heal (1979) emphasized, this result implies that a SWF being continuous, Paretian, and satisfying the independence, stationarity and monotonicity axioms must take the form of a discounted sum of generations' utilities. Therefore this suggests that some "pure" discounting should be made. Regarding Koopmans's derivation, Heal (1998) argued that the independence axiom constitutes a strong requirement: it implies that the trade-off between what happens today and what happens at a given point in the future does not depend on events occurring in the meantime. This might weaken Koopmans's axiomatic argument. However, if we consider, as in Dasgupta (1988), that Koopmans's analysis addressed potential ethical norms that a planner's preferences should satisfy, then the fact that the independence axiom is a strong assumption does not weaken Koopmans's argument.

More recently, Epstein (1986) showed that there exists no preference ordering that satisfies the axioms of equity, effectiveness[29], consistency[30], monotonicity, partial transitivity and substitution[31]. As we stressed above, there is strong empirical evidence against the consistency axiom. However, as Epstein noticed, it makes sense to impose it on preference orderings, because one might require from such orderings to resolve the intergenerational conflicts.

But axiomatic arguments might also support a zero discount rate. For instance, Cowen (1992) showed that the axioms of Pareto indifference[32], transitivity of indifference relation, person neutrality within generations[33] and the axiom of well-defined preferences across living in different eras[34], if joined with consequentialism, imply that one additional unit of utility for the current generation is equally good as one additional unit of utility for the future generation. Cowen derived such intergenerational neutrality from intragenerational neutrality by extending the individual preference space across eras, and by assuming the transitivity of indifference. Regarding the reasonableness of his axioms, Cowen considers that Pareto indifference is reasonable in his context where he compares situations similar regarding non-welfarist information. However, the axiom of transitivity of indifference relation, as Cowen argued, is contradicted by the Sorites Paradox, according to which comparisons of pairs of quasi-similar bundles may generate intransitivity of indifference. But Cowen argued that there were no quasi-similar bundles involved in his demonstration, so that the use of that axiom might be justified. Regarding the axiom of well-defined preferences across living in different eras, Broome (1992) wondered whether that axiom, which requires an individual to have preferences about when to life before he actually lives, is reasonable. Therefore Cowen's axiomatic argument for no discounting under certainty does not seem fully convincing.

Another axiomatic argument in favour of a zero "pure" discount rate was developed by Blackorby, Bossert and Donaldson (1995). Blackorby, Bossert and Donaldson showed that

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[28] In that later paper, Koopmans (1966) derived the existence of a continuous utility function from postulates on preference orderings (continuity, sensitivity, independence, stationarity and monotonicity).

[29] Requiring that the preference ordering permits the choice of maximal elements.

[30] Requiring that there exists at least one consumption path that is maximal for the first generation and that remains maximal for infinitely many succeeding generations.

[31] Requiring that it is possible to improve any positive path by reducing the consumption in the initial period and by changing the consumption of later generations.

[32] Requiring that "two situations are equally good if the same two situations are equally good for all the persons involved" (Cowen, 1992, p. 163). This implies that one should be indifferent with respect to policies that do not benefit to anyone and harm no one.

[33] This axiom states that "a benefit for one person is equally good as the same benefit for another person within the same generation, ceteris paribus" (Cowen, 1992, p. 163).

[34] According to Cowen (1992, p. 164), "preferences are well-defined [across living in different eras] if persons would be willing to engage in permanent time travel in exchange for some amount of money or resources".

the axioms of Strong Pareto[35], anonymity and continuity rule out the possibility of "pure" discounting in a welfarist framework. As they argued, the axiom of Strong Pareto, implying Pareto indifference (also present in Cowen, 1992), plays a crucial role in that result. Indeed, if some level of lifetime utility is associated with a person's life, then Pareto indifference implies that, provided that person's lifetime utility does not vary if the person's birth takes place in another period, the date of birth of that person cannot make a difference from a social point of view. Hence the time of the utility does not matter, so that the possibility of "pure" discounting is ruled out.

Which conclusions could be drawn from those axiomatic arguments? Firstly, their approach is purely normative, so that empirical arguments against the postulated axioms are here irrelevant. Here axioms can only be judged in the light of their reasonableness. Secondly, as Dasgupta and Heal (1979) pointed out, "incompatibility" arguments do not tell us which axiom should be dropped. Thirdly, and more importantly, those axiomatic arguments do not constitute, in my view, simple mathematical exercises. Rather, they show that some incompatibilities might appear between different ethical requirements imposed on a social welfare function[36], and, by doing so, they ask crucial questions regarding the status of social evaluation criteria: what should we require from a social welfare function? Behind that question, this is the whole issue of the status of ethical knowledge and of the role of reason in ethics that are raised.

To summarize, it seems to me that there might be no completely convincing argument supporting "pure" discounting under the assumption of a certain world. Indeed, arguments based on democracy or on consumers' sovereignty do not seem to stand up to criticisms. Moreover, as Kavka (1978) argued, evoking the temporal distance of future people or our ignorance of their detailed desires, in order to avoid obligations towards them, might not be ethically tenable. Another crucial point was stressed by Parfit (1984): assigning higher weights to the people near to us does not allow us to ignore completely people very distant in the future, as it would result from the use of a positive "pure" discount rate. In my view, the most convincing arguments are the ones developed by Koopmans (1967a, 1967b) and Dasgupta and Heal (1979). While the former raised the issue of the potential impossibility to select an optimal infinite consumption path under a zero discount rate, the latter stressed the fact that a zero discount rate might lead to a sub-optimal solution in a model of exhaustible resources. However, those two arguments concern particular cases, and thus cannot support a generalized use of a positive "pure" discount rate[37]. Regarding axiomatic arguments, it should be stressed that their evaluation remains difficult: being of a normative kind, those arguments are immunized against any empirical criticisms. This leaves us with only one criterion to assess them: the "reasonableness" of their postulated axioms. But the issue of the "reasonableness" of the properties that a pragmatical social welfare function should exhibit raises the complex questions of the nature of ethical knowledge, and of the role of reason in ethics. Those difficult questions go infinitely beyond the issue of the "pure" discount rate debate. Therefore it seems to me that axiomatic arguments cannot constitute an ultimate argument for or against "pure" discounting. Hence no completely convincing argument seems to support impartiality under certainty.

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[35] Blackorby, Bossert and Donaldson (1995) defined the Strong Pareto requirement as follows (see p. 1307): (i) if all individuals in the society have the same individual utility levels under alternatives A and B, then A and B must be socially indifferent (Pareto indifference); (ii) if all individuals are at least as good under A as under B, with at least one individual strictly better in A than in B, then A must be socially preferred to B.

[36] Formal incompatibilities between "reasonable" axioms in the context of intergenerational equity have been widely discussed by Fleurbaey and Michel (1997).

[37] Moreover, the strength of Dasgupta and Heal's (1979) argument seems weakened once it is acknowledged that there exists no optimal positive "pure" discount rate under the assumption of decreasing marginal benefits from depletion (see *supra*).

4: The uncertainty argument for a positive "pure" discount rate

Uncertainty being a central feature of the future, one cannot ignore it when one thinks about future generations. Regarding the "pure" discount rate debate, the presence of uncertainty might play a crucial role, as this section will show. Indeed, uncertainty about future people's lives might justify the use of greater weights for near generations whose existence is more certain, and of lower weights for future generations, whose existence, being more distant in time, might also seem more conditional[38]. Therefore, uncertainty is not something trivial added to the moral exercise, and cannot be treated simply as a technical complication. It should also be stressed that there exist many other sources of uncertainty: for instance, the uncertainty about the effects of our current policies on future people that will exist for sure. But in this section, I shall mainly confine myself with the uncertainty regarding future generations' existence[39].

Kavka (1978) pointed out that future people's existence is uncertain: future people might simply not exist at all. According to Kavka, the contingency of future people's lives might justify that some priority should be given to existing people in situations of scarcity of resources. However, this does not imply that one should have no obligations towards the people one knows they will exist: those people whose future lives are known should receive the same treatment as the one of current people. Moreover, if there is no scarcity (in the sense of exhaustibility of resources), everyone should be treated equally. Indeed, uncertainty is here about future people's existence, or, in other words, about future people's number. But, as Kavka argued, this is not necessary to know the exact number of future people; what matters is that we know that there will be many future people, with basic needs similar to ours (see above). As Attfield (1983) argued, even if we do not know the precise number of future people, we can be "very nearly certain" that many future people will live in the future, so that we should take their existence as given, and treat their interests as ours. That "quasi-certainty" might appear sufficient to justify some moral obligation towards future people, and thus to reject the use of a positive "pure" discount rate that would contribute to neglect very distant future people[40]. But it still remains that "quasi-certainty" of future people's existence is not equivalent to a complete certainty of their existence. The slight difference between "quasi-certainty" and certainty of future people's existence might be used to justify the use of a positive "pure" discount rate.

This distinction constitutes the basis of Dasgupta and Heal (1979)'s argument. Indeed, Dasgupta and Heal argued that positive discounting is justified by the existence of a positive non-zero probability of extinction of mankind. In other words, positive discounting is a way to account for the fact that each generation is slightly less likely to exist than the previous one. Dasgupta and Heal developed their argument for positive discounting under uncertainty by extending Harsanyi's (1955) "veil of ignorance" argument, based on the concept of "ethical preferences"[41]. In short, their argument goes as follows. Suppose a generation, consisting of

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[38] The practice of discounting for the possibility of extinction was used in the growth literature, even prior to Dasgupta and Heal's (1979) argument, for instance by Mirrlees (1965).

[39] On the uncertainty of our effects on future people in general, see Smart and Williams (1973), and Parfit (1984).

[40] Moreover, Kavka suggested that some – not extreme – restrictions of the future population might be morally acceptable, in order to limit future generations' needs. The issue of future numbers and of (average and total) utilitarian population policies, has been covered in depth by Parfit (1984).

[41] Harsanyi firstly formulated his argument in another article (1953).

one rational individual[42], who must choose the optimal infinite consumption stream for the society. Suppose that he puts himself under a "veil of ignorance", that is, he forces himself to forget the generation he belongs to, so that he faces a choice under uncertainty. Facing such an uncertainty, the individual will choose the infinite consumption stream maximizing his expected utility[43]. According to Harsanyi (1955), the individual's "ethical" preferences, in contrast with his "subjective" preferences, must be "impartial" and "impersonal", so that the individual must assign equal probabilities to all the potential social positions. As Dasgupta and Heal mentioned, one could justify "equi-probability" by assuming that the choosing party follows Laplace's Principle of Insufficient Reason, according to which, when one has no evidence at all, one assigns equal probability to each possible case.

In an infinite intergenerational framework, however, there are an infinite number of potential social positions. Therefore, as Dasgupta and Heal (1979) underlined, talking about "equi-probability", when the future is infinite, makes no sense: one cannot have a uniform probability distribution defined over the infinite set of integers[44]. However, as Dasgupta and Heal underlined, the probability of extinction is not zero. One way to introduce it is to denote λ_t the subjective probability formed by the choosing party at $t = 0$ that human life on the Earth will cease at a date beyond t. Then the choosing party will choose the infinite consumption stream maximizing $W = \sum_{t=0}^{\infty} \lambda_t U (c_t)$, where $\lambda_t > 0$.[45] If we consider, by definition, that $\lambda_t > \lambda_{t+1}$ for all t, then that expression might justify a positive discount rate[46]. Therefore, there seem to be strong ethical foundations for a positive discount rate under uncertainty. However, Dasgupta and Heal's argument might be criticized on several grounds.

Firstly, it should be stressed, as Parfit (1984) underlined, that one should distinguish the temporal discount rate from the "probabilistic" discount rate (discounting for predictions which are less likely to be true). Parfit acknowledged that, in general, those two discount rates (temporal and probabilistic) roughly correlate. However, according to Parfit, they are quite different, so that it would be a mistake to discount for time rather than for probability: by doing so, we would claim, not that more distant bad consequences are less likely, but rather that they are less important, which is not the same. Moreover, Parfit argued that the two discount rates might not correlate (some predictions, when applied to the further future, being more likely to be true). I personally agree with Parfit on his distinction between temporal and probabilistic discount rates. But I think that, when we want to account for a probability of extinction, the two discount rates might be sufficiently correlated: if we assume that each generation is slightly less likely to live than the previous one, so that, when we go further in time, the likelihood of existence is reduced, then, there is no reason for treating uncertainty separately: we can use a temporal discount rate, which is in fact a probabilistic one. However, when we use such a discount rate, we must keep in mind that this is not because we give

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[42] "Rational" in the sense that the individual's preferences satisfy the Von-Neumann-Morgenstern axioms of rational behaviour under risk, or the Marschak postulates equivalent to them (complete ordering among all prospects, continuity, sufficient number of non-indifferent prospects, equivalence of mixture of equivalent prospects).

[43] The individual's expected utility is given by (Dasgupta and Heal (1979), eq.9.7, p. 273):

$W = \sum_{t=0}^{\infty} \pi_t U (C_t)$

where π_t is the subjective probability of being a member of generation t, and $U(C_t)$ accounts for generation t's attitude towards risks.

[44] As Dasgupta (2001) argued, the only way to give sense to "equi-probability" in this context would be to assume that the probability of extinction over the indefinite future is unity.

[45] Dasgupta and Heal (1979), eq.9.8, p. 274. For convenience, Dasgupta and Heal assumed the possibility of intergenerational comparisons of utilities.

[46] Dasgupta and Heal stated that, "by definition", $\lambda_t > \lambda_{t+1}$ for all t, because λ_t is a probability, so that the sum of the λ_t's – an infinite sum – must be equal to one. Given that $\lambda_t > 0$, this can only be obtained if $\lambda_t > \lambda_{t+1}$ for all t (an infinite sum of constant or increasing terms could not be equal to unity).

lower weights to future generations from a moral point of view, but because the likelihood of existence of future generations is lower when we go further in the future, which has nothing to do with morality or impartiality[47].

Being based on Harsanyi's (1955) axiomatic derivation of average utilitarianism, Dasgupta and Heal's argument for positive "pure" discounting might also be subject to some of the criticisms formulated against Harsanyi (1955)'s initial argument. For instance, one might argue, as Barry (1989), that there is no reason for identifying moral judgements with judgements made behind a "veil of ignorance". However, Broome (1991) considered that critique to hold for Harsanyi's (1953) first argument, but not for Harsanyi's axiomatic derivation (1955). Given that Dasgupta and Heal's argument is based on the latter, their argument is not weakened by that criticism.

Given that Harsanyi's (1955) original axiomatic derivation of average utilitarianism was criticized severely by Rawls (1971), one might wonder whether Dasgupta and Heal's argument is also subject to Rawls' criticisms. Firstly, Rawls argued that there does not seem to be objective grounds in the initial situation for assuming that one has an equal chance of being anybody. One justification could be to suppose that the individual forms his probabilities by following Laplace's Principle of Insufficient Reason. However, in his own theory, Rawls considered that the ignorance behind the "veil" was such that the individual could not form any probability distribution. Therefore Rawls preferred the non-probabilistic maximin criterion. However, as Sen (1970) underlined, equi-probability in Harsanyi (1955)'s framework comes from the fact that Harsanyi required "ethical" preferences to be "impersonal", and defined his "impersonality" in terms of "as if equi-probability". Thus if we adopt Harsanyi's definition of ethical preferences, we must also adopt the resulting "equi-probability". I think that Dasgupta and Heal's extension of Harsanyi's argument is also based on that condition for "impersonal" choice. Therefore, their argument is not affected by Rawls's criticism. Moreover, Rawls (1971) also argued that the expectations resulting from Harsanyi's rationale were spurious for two reasons. Firstly, those expectations are not based on one system of aims, in the sense that the individual computes the expected utility of being everybody, by taking each individual's systems of ends. Hence, Rawls argued that such expectations are meaningless. A second, related argument is that it is impossible for an individual to assess the value of each of the "total circumstances" of others, without any reference to his own conception of the Good. Hence, according to Rawls, an individual behind a "veil of ignorance" cannot assess the value of each social position. Those two criticisms seem to weaken Harsanyi's original argument. However, they do not weaken Dasgupta and Heal's argument, simply because their argument is based on the assumption that all generations have identical preferences (while Harsanyi's argument is not). Therefore Dasgupta and Heal's argument does not seem to be affected by those two criticisms by Rawls[48].

Another objection made to Harsanyi's analysis was expressed by Diamond (1967) and Sen (1970), who argued against the adequacy of the expected utility axioms for social decision-making. According to Diamond and Sen, the independence axiom does not allow the impartial individual to take into account the distributive aspects of the resulting outcomes. However, in social choices, one would like to know more than the mathematical expectation

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[47] I shall come back on the validity of the assumption of "sufficient correlation" between time and likelihood of existence further in this essay.

[48] Dasgupta and Heal justified that assumption by arguing that the aim of it was "to make the moral calculation simple". But, according to what is argued above, that assumption has also the virtue to immunize their argument against some Rawlsian criticisms. One could argue that such assumption should be relaxed, because a choice under a "veil of ignorance" would have more meaning if all generations did not have the same preferences. However, in that case, then Dasgupta and Heal's moral calculation would not only be more difficult to compute, but it would also be subject to the two criticisms formulated by Rawls against Harsanyi's (1955) argument.

of welfare under a veil of ignorance, but also the precise distribution of welfare over individuals. In order to emphasize that point, Diamond (1967) developed the example of a society composed of two individuals A and B, which faces a choice between two alternatives α and β, with two equally possible states of nature, θ_1 and θ_2. The utility levels under each contingency are given in the following table[49]:

	If θ_1 occurs	If θ_2 occurs
Alternative α	$u_A = 1, u_B = 0$	$u_A = 1, u_B = 0$
Alternative β	$u_A = 1, u_B = 0$	$u_A = 0, u_B = 1$

As Diamond argued, a SWF resulting from Harsanyi's axiomatic derivation would be indifferent between the two alternatives α and β. However, it seems obvious that, from a social point of view, alternative β is more desirable than alternative α – and even "strictly preferable", according to Diamond –, because under alternative β each individual has the same expected utility equal to ½, while, under alternative α, the expected utility of individual A is 1 and the expected utility of individual B is 0. Hence alternative β seems more socially desirable than alternative α because it is more equitable. However, the expected utility theory would lead to indifference between those two alternatives, because it has no distributive considerations: the only relevant information it requires is the total expected utility under each alternative (that is equal to 1 under each alternative). In my view, Diamond and Sen were definitely right when they argued that social choices, as opposed to individual choices, require more information than the total expected utility, but also information about the distribution of welfare among the society. That criticism remains relevant for intergenerational choices considered in Dasgupta and Heal (1979): one could expect from the choosing party to take into account in its choices not only the expected utility under "veil of ignorance", but also the whole distribution of welfare between generations. Hence Dasgupta and Heal's argument seems to suffer from the same weakness as Harsanyi's initial argument. Dasgupta and Heal's assumptions on the choosing party's behaviour might not be completely satisfactory, so that their result – at least indirectly – seems to be weaken by Diamond and Sen's critique.

As Weymark (1991) noticed, Sen (1986) also criticized Harsanyi's framework for not providing an axiomatization of utilitarianism, but rather a representation theorem of the underlying social preferences. Sen's criticism is based on the idea that Harsanyi's concept of utility is not independent of the concept of preferences. In other words, Sen suspects Harsanyi to use a concept of utility taking the sense of "numerical representation of preferences". However, as Sen and others noticed, that third meaning of utility cannot constitute a basis for utilitarianism. Indeed, as Weymark (1991) rightly emphasized, utilitarianism requires the social ordering to be derived from the social welfare function, and not the inverse. Moreover, under the third meaning of utility, utility is only ordinally measurable but not comparable: thus they cannot be used as a basis for utilitarianism, requiring cardinality and interpersonal comparisons of utilities. However, according to Weymark, there seem to be some "clues" in Harsanyi's work that his concept of utility represents more than preferences only. Therefore, according to Weymark, Sen's interpretation of Harsanyi's theorem as a representation theorem might not be completely justified[50]. Regarding Dasgupta and Heal's framework, it should be stressed that they make the assumptions of cardinal utilities and of possible

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[49] See Diamond (1967), p. 765-766.
[50] For a complete treatment of the "Sen-Harsanyi debate", see Weymark (1991).

intergenerational comparisons of utility, so that their demonstration is immunized against the criticism under discussion here.

Williams (1978) formulated some criticisms against the general practice of discounting under uncertainty. Firstly, according to Williams, if the human kind faces at some point in the future a danger of extinction, against which humans can do something, then human beings will be more likely to survive if they have more scarce resources. Therefore, rather than discounting for the possibility of extinction, and thus giving more weights to current people and lowering the probability of survival of human species, a society should not use any discount rate, because no discount would definitely be the best way to prevent extinction. This argument is clearly based on the assumption that humans could act in some way to avoid the extinction. However, if there is nothing to do to prevent the extinction, then discounting might be still justified. Therefore, if Dasgupta and Heal's argument is about an uncertainty regarding an unavoidable extinction of human life on the Earth, then it remains immunized against Williams' argument. Secondly, Williams also argued that a society should not use a discount rate, except if extinction is, in Williams's words, a "clear and present certainty". Williams warned us against a simplistic analogy: this is not because individual lives are finite that the human life as a whole must necessary have a finite life-time: while each individual can be completely certain that he will die before some time in the future, let us say, before he reaches the age of 150 years, it is not completely certain that human life as a whole will disappear before some point of time in the future. Hence a society should not use a discount rate as the individuals do. However, I think that Dasgupta and Heal's argument is not based on a simplistic analogy with an individual's finite life. The discount rate they would recommend would definitely not correspond to the discount rate an individual would use. Therefore their argument seems to be immunized against that criticism.

Another possible objection to Dasgupta and Heal's derivation might concern the formation of the probability of extinction by the choosing party. Dasgupta and Heal assumed that the probability of extinction of human life takes the form of a "subjective" probability, thus a probability that could be derived by the choosing party. However, as Smart (1973) underlined, what utilitarianism requires is "a method of assigning numbers to *objective*, not subjective, probabilities"[51], simply because individuals, being irrational about their moral thinking, could also be irrational regarding the subjective probabilities they would form. Therefore utilitarianism, which needs solid theoretical foundations, must be based on a theory of objective probabilities. According to Smart, a potential solution to that problem could be to accept a method assigning subjective probabilities, and then to define objective probabilities as the subjective probabilities "of an unbiased and far-sighted man"[52]. As Smart noticed, this would require independent criteria of absence of bias and of farsightedness.

Regarding the first requirement ("lack of bias"), all what is said in Dasgupta and Heal's framework regarding the way the choosing party forms his subjective probabilities is that the choosing party, being under a veil of ignorance, does not know the generation he belongs to. This implies that the choosing party will probably not be biased in his formation of the probability of extinction. If the choosing party was not under a veil of ignorance, then he would voluntary choose a high probability of extinction, because his knowledge of belonging to the current generation would give him an incentive to choose a high probability of extinction leading him to be biased in favour the generation he belongs to. But such a bias cannot exist in Dasgupta and Heal's framework. Hence their approach satisfies Smart's requirement of the probability maker's lack of bias. But what about the second requirement, his "farsightedness"?

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[51] Smart (1973), p. 41.
[52] Smart (1973), p. 41.

How "farsighted" is the choosing party? In fact, Dasgupta and Heal's derivation of a positive discount rate does not require that the choosing party really knows the exact probability of extinction of human life on the Earth. Indeed, as it was stressed above, the justification of a positive discount rate depends only on the assumption that λ_t, the probability, at $t = 0$ that the world will terminate at a date beyond t, is strictly positive, and on the assumption that $\lambda_t > \lambda_{t+1}$ for all t, that is, the assumption that the probability of the world ending beyond some date is decreasing when we consider a more distant date in the future. However, that second assumption is automatically implied if we assume that the choosing party has a λ_t strictly positive and a consistent set of probabilities. Therefore, Dasgupta and Heal's derivation of a positive discount rate requires, in some sense, some farsightedness on the part of the choosing party: indeed, even if it is not assumed that the choosing party knows the exact value λ_t and its whole distribution, the choosing party still needs some farsightedness in order to be able to form a consistent set of probabilities over an infinite number of potential future generations. Therefore, Dasgupta and Heal's derivation of a positive discount rate seems to satisfy Smart's requirements.

But this leads us to another potential criticism against Dasgupta and Heal's argument. Indeed, one could argue that Dasgupta and Heal's framework, assuming that the choosing party can compute the whole distribution of λ_t's over an infinite number of potential future generations, would be too demanding regarding the ability of the choosing party to form his subjective probabilities. In other words, one might argue that Smart's second requirement of "farsightedness" might be more than satisfied. One could claim that the assumptions underlying the choosing party's behaviour are too extreme and unjustifiable. Indeed, the choosing party is not only assumed to be very farsighted, in order to be able to form his probabilities over an infinite number of future generations; he is also assumed to be consistent in his choice of probabilities, that is, he chooses his probabilities in such a way that their infinite sum is exactly equal to one. In front of such assumptions, one might wonder whether these are reasonable. How could the choosing party derive his subjective probabilities in such a complex case?

Before turning to that question, it might be worth emphasizing the following crucial point. It should be stressed that the nature of Dasgupta and Heal's argument is purely normative. Therefore it does not matter at all whether "normal" people do actually behave or not according to Dasgupta and Heal's assumptions. Dasgupta and Heal are concerned with how a choosing party, being rational and impartial, ought to make his choices for the whole society. Therefore the discussion on the degree of assumed farsightedness cannot weaken their normative argument in any way. However, I think that it might still be worth discussing here the assumptions on which the "probabilistic" discount rate argument is based, in order to distinguish the crucial assumptions from the less important ones.

It should be stressed that Dasgupta and Heal's argument does not require that the likelihood of human life has a probability zero after some time t. However, what it requires is twofold: firstly, that λ_t is strictly positive for all t, and, secondly, that the choosing party has a consistent set of probabilities (so that λ_t is strictly greater than λ_{t+1} for all t). The first requirement rules out a zero λ_t, that is, it excludes the case where the choosing party would assign a zero probability to the possibility of the world terminating at a date beyond t. Therefore that requirement actually rules out two cases: (i) the case of the choosing party being completely certain that human life will last forever; (ii) the case of the choosing party being completely certain that human life will end before a date t. Regarding the second requirement, that is, that the choosing party forms a consistent set of probabilities (which implies that λ_t strictly greater than λ_{t+1} for all t), it rules out two cases: (iii) the case where the choosing party is certain that generation t+1 is strictly more likely than generation t for all t, and (iv) the case where the choosing party considers that generation t and generation t+1 have

exactly the same likelihood of existence. Could all the cases (i) to (iv) be ruled out? In order to answer that question, I will firstly focus on cases (i)-(ii), and leave cases (iii)-(iv) and the issue of the consistency of the probability formation, for later.

If we assume that the choosing party forms a consistent set of probabilities (and thus rules out (iii) and (iv)), the strength of Dasgupta and Heal's argument seems to depend on the answer to the following questions. Could a "subjective" probability maker be completely certain that human life will last forever (i)? Could a "subjective" probability maker be absolutely certain that human life will end before date t (ii)? If one answers "yes" to one of those two questions, then this might weaken Dasgupta and Heal's assumptions on the probability λ_t, and thus their derivation of a positive discount rate.

In order to try to answer that question, we must think about the concept of subjective probability. According to Allais (1983), the concept of probability does not exist in nature; it only exists in human minds. The concept of probability, Allais argued, "corresponds to a human judgement made in advance by a human mind"[53]. Allais distinguishes four concepts of probability: mathematical frequency, empirical frequency, objective probability and coefficient of plausibility. Given that the first of those concepts is fully deterministic, while the second of them deals with events that have already occurred, we can only focus here on the last two concepts. According to Allais, when one makes forecasts based on already observed statistical distributions, one uses the concept of objective probability. However, when forecasts cover events that have never been subjected to statistical analysis, then those forecasts are based on what Allais calls "coefficients of plausibility". But, as Allais argued, any consideration of plausibility is inherently subjective, in the sense that the forecast of the future is then detached from any element independent of the individual making the forecast. But, even expressed in terms of "plausibility", our question remains: how could the choosing party assess the plausibility of existence of an infinity of future generations? Plausibility is a matter of degree, and, in order to assess the degree of plausibility an individual assigns to a contingency, it might be helpful to come back to the foundations of the theory of subjective probability developed by Ramsey (1926) in his posthumously published *Truth and Probability*.

According to Ramsey (1926), probability theory is a theory of partial beliefs. Subjective probabilities can be regarded as degrees of beliefs. This is the reason why, roughly speaking, if one wants to know the probabilities that an individual forms, one must try to measure the beliefs of that individual. Ramsey believed that beliefs could be, to some extent, measurable[54]. The way Ramsey suggested to measure beliefs was the following: the degree of a person's belief in something might be expressed as the extent to which that person would be prepared to act on it. In Ramsey's words[55], "the difference [between believing and not believing] seems […] to lie in how far we should act on these beliefs". However, as Ramsey underlined, this does not mean that beliefs automatically lead to actions; it will only be the case in some particular circumstances: actions are led, according to Ramsey, by beliefs and desires.

Regarding the discounting issue, it follows that we can look at the choosing party's subjective probabilities as representing his beliefs regarding the existence of future generations. Keeping this in mind, one might judge the relevancy of cases (i) and (ii) by wondering whether a choosing party would be willing to act or not on the beliefs expressed in cases (i) and (ii). If not, then ruling out cases (i) and (ii) might seem justified. In my view, a choosing party would not be willing to act on the beliefs expressed in those two cases. Indeed, those beliefs are so extreme that it is difficult to imagine an agent being willing to act on such

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[53] Allais (1983), p. 48.
[54] However, Ramsey (1926, p. 63) stressed two crucial points: firstly, not every belief can be measured with the same precision; secondly, the measure of a belief might depend on the way the measurement is realized.
[55] Ramsey (1926), p. 66.

beliefs. On the one hand, I think it would be difficult for a choosing party to be 100 % certain that human life will last forever, because we do not know many things regarding the conditions of life on the Earth for the next billions of years. Hence the eternity of human life cannot be regarded as completely certain. Therefore I cannot imagine a choosing party choosing actions based on the belief of eternal life on the Earth. On the other hand, I do not think that a choosing party could be absolutely sure that life will end before some date in the future. Would such a person be willing to act on such beliefs? I do not think he would. Therefore, beliefs present in cases (i) and (ii) seem rather extreme and untenable, and I am not sure that a choosing party could act on these beliefs. Therefore, the fact that cases (i) and (ii) are ruled out by Dasgupta and Heal's assumptions on λ_t does not seem to me to be problematic.

Regarding cases (iii) and (iv), it should be stressed that they are directly implied by the implicit assumption that the choosing party forms a consistent set of probabilities. Indeed, if the choosing party forms a consistent set of probabilities over an infinity of potential existence of future generations, then it results, by definition, that λ_t is strictly greater than λ_{t+1} for all t. Indeed, a consistent set of probabilities could not contain an infinity of increasing λ_t, because the sum of those λ_t's could never be equal to one. Therefore the consistency requirement rules out cases (iii) and (iv) automatically. It should be stressed that, in general, there is no contradiction between the consistency requirement and the interpretation of probabilities as degrees of partial beliefs on which one would be willing to act. Indeed, as Ramsey (1926) rightly underlined, no one would be willing to act according to an inconsistent set of beliefs: if one is told that his beliefs are inconsistent, that person will probably try to change his beliefs and make them consistent before acting on their basis. Therefore there is usually no conflict between those two interpretations. This is clearly showed when one considers case (iii). Obviously, the beliefs expressed in case (iii) do not only violate the consistency requirement, but it seems clear that no one would be willing to act on such beliefs[56]. However, this is less obvious regarding case (iv). Case (iv) is the case where the choosing party is absolutely certain that generation t and generation t+1 have exactly the same likelihood of existence for all t. Such a belief clearly violates the consistency requirement. However, is this so obvious that the choosing party would not be willing to act on such a belief? I think that if the choosing party is told that such a set of beliefs is inconsistent, then he will probably change his set of beliefs, and therefore will not act on the basis of his initial set of beliefs. It might be possible that, intuitively, the choosing party might have formed an inconsistent set of partial beliefs, for instance might have believed that two successive generations t and t+1 have exactly the same likelihood of existence. Such a belief might seem reasonable, and it is not unthinkable to consider that most people would act today on their belief that tomorrow's existence is as likely as today's existence. However, together with a strictly positive λ_t and a potentially infinite horizon, this would lead us to an incoherent set of beliefs. Having realized that his beliefs were not coherent, the choosing party might then have changed his beliefs, simply because he knows that an incoherent system of beliefs is a bad guide for action. Thus the choosing party might have adapted his set of partial beliefs, to make it consistent and hence the best guide for action. That kind of "adaptation" requires a high level of rationality, and this is not sure that most people would accept to change their beliefs to make them consistent. However, from a normative point of view, this is what we might expect from a rational impartial individual making decisions for the whole society.

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[56] Indeed, it would be difficult to argue that a future generation is more likely than the generation preceding it. The reason why this is not defendable is that the existence of a generation seems conditional on the existence of the preceding generations. If generation t is not very likely to exist, it implies that human kind is likely to disappear at time t, and thus the next generations could not be more likely to exist. Hence positive correlation between time and likelihood of existence seems inadequate.

Therefore, as I stressed above, this discussion does not weaken Dasgupta and Heal's derivation of a positive discount rate, because their approach is purely normative. But what it suggests is rather that their results depend crucially on their assumptions on the formation of the subjective probability of extinction beyond some future period. Dasgupta and Heal assumed not only that the choosing party was farsighted enough to form his own probabilities over an infinite number of future generations; they also assumed that the choosing party did it in a consistent way. Those assumptions, with the assumption of a strictly positive λ_t, were necessary and sufficient to obtain the result that time and likelihood of extinction are positively and sufficiently correlated – result that was crucial to justify the use of a "temporal" discount rate as an approximation to a "probabilistic" discount rate.

To summarize, it follows from this discussion that Dasgupta and Heal's appealing derivation of a positive discount rate in order to account for a possibility of extinction of human life on the Earth might be potentially attacked on two main grounds: firstly, its "Harsanyian" foundations, and, secondly, its assumptions regarding the formation of the probability of extinction beyond some date in the future. Regarding the first source of objections, it was showed that Dasgupta and Heal's framework seems to be immunized against most criticisms. Only one criticism seems to remain: the one, developed by Diamond and Sen, of the inadequacy of the expected utility theory and of its independence axiom in order to deal with intergenerational fairness. Regarding the second source of criticisms, our discussion emphasized that Dasgupta and Heal's result depends crucially on the assumptions that the choosing party not only satisfies the "absence of bias" criterion, but also that is supposed to be extremely farsighted (to form his probabilities in such a complex framework where an infinity of contingencies is involved) and consistent in his formulation of probabilities (to have an infinite sum of probabilities summing up to one). Those two latter assumptions, with the assumption of a strictly positive probability of extinction beyond some date in the future, are necessary and sufficient to obtain the negative perfect correlation between time and the likelihood of existence of future generations, and hence a positive discount rate. All this together might seem difficult to justify, even if Dasgupta and Heal's approach is purely normative, and thus is not weakened by the strength of those assumptions. Therefore it seems to me that Diamond and Sen's critique is probably the strongest criticism against the "probabilistic" argument for a positive discount rate. However, despite that critique, I personally think that the introduction of uncertainty about future people's existence, although it does not completely bring the discounting debate to its end, seems to provide a strong support to the use of a positive discount rate. But it should be stressed, following Parfit (1984)'s crucial remark, that when we apply a discount rate to account for uncertainty of future people, the discount rate we use is actually a probabilistic discount rate, which takes the form of a temporal discount rate for convenience. Therefore, discounting for uncertainty is not in contradiction with some intergenerational "impartiality" requirement, even if, at the end of the day, such a practice recommends lower weights to be assigned to future generations' welfare.

5: Conclusions

In conclusion, the "pure" discount rate debate, launched by Ramsey in his famous *A Mathematical Theory of Saving* (1928), has been very fruitful for the last forty years, thanks to the numerous contributions made by leading philosophers, economists and mathematicians. Such a rich debate was definitely difficult to explore, even in a non-exhaustive way, in those few pages. This is much more difficult to summarize it in this conclusion. However, I think that a few concluding remarks could be made.

First of all, if we remain under the simplified assumption of complete certainty regarding future people's lives, it seems to me that there may be very few fully convincing arguments in favour of "pure" discounting. In my view, the most convincing arguments are the ones of the impossibility to select an optimal infinite consumption path (Koopmans) and the argument of the sub-optimality of a zero discount rate in a situation of exhaustible resources (Dasgupta and Heal). However, those arguments concern particular cases and are not fully convincing. Regarding axiomatic arguments, it should be stressed that, even if they do not provide an ultimate uncontroversial argument for discounting, they emphasize some potential tensions between the impartiality requirement (zero discount rate) and other requirements that one might expect from social welfare functions. But, in my view, those tensions, rather than being kinds of "paradoxes" that could be easily solved mathematically by adjusting some requirements, ask us some crucial questions regarding what we should require from a social evaluation criterion. This leads us to the difficult questions of the role of reason in ethics, and of the status of ethical knowledge in general.

Once we introduce some uncertainty regarding the existence of future people, it seems to me that the case for a positive discount rate is stronger, as Dasgupta and Heal argued, by developing their "probabilistic" argument for a positive discount rate under uncertainty. However, it should be mentioned that the resulting temporal discount rate, or "pure" discount rate, is, as Parfit rightly underlined, nothing else than an approximation for a probabilistic discount rate, which does not violate any "impartiality" requirement: it only takes into account the less likely existence of future generations. However, this use of one discount rate as an approximation of another can only be made if there is a sufficient (negative) correlation between time and likelihood of existence. It was showed that such a correlation was derived by Dasgupta and Heal, on the basis of several assumptions on the way the choosing party, under a veil of ignorance, forms his probabilities. Those strong assumptions might be justified on the grounds that Dasgupta and Heal's "probabilistic" argument for a positive discount rate is purely normative: hence their requirements simply correspond to what one might require from a rational impartial choosing party making social choices. However, Dasgupta and Heal's argument, exactly like Harsanyi's initial derivation, is subject to Diamond and Sen's critique, according to which social choices should not be based on the expected utility theory only. From a normative point of view, one might require from a choosing party to take into account, in his decisions, not only the social expectation of welfare, but also the entire intergenerational distribution of welfare. Therefore, Dasgupta and Heal's argument might not be completely immunized against criticisms, and hence does definitely not bring the "pure" discount rate debate to its end.

That incapacity to bring the discounting debate to its end might not be very surprising. Indeed, it would seem rather unlikely that ethical issues – such as the one of the choice of the weights to be assigned to future generations – could ever be solved completely. Such issues might belong to the ones that remain eternally debated. One could seriously wonder whether any ethical argument – whatever its form – could ever convince everyone and resist any criticisms. However, this does not necessary imply that no progress has ever been – or could ever been – made in ethical issues. In my view, the present survey, concerned with utilitarian intergenerational ethics, might have shown that some "advances" in the "quality" of the arguments developed might have been achieved in the last 40 years. The introduction of uncertainty, for instance, might constitute a definite "advance": a human being making moral choices cannot escape from his limited knowledge of the future, whatever his moral certainties are. Acknowledging that uncertainty cannot be removed out of moral choices, but rather, that it constitutes a non-negligible component of these, might be regarded as opening new doors allowing further ethical inquiries, even if, due to the mere nature of the question asked, it is unlikely to bring the debate to its end.

6: References

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