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Technology Assessment between Risk, Uncertainty and Ignorance

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Technology Assessment between Risk, Uncertainty and Ignorance

Abstract: The use of most if not all technologies is accompanied by negative side effects, While we may profit from today's technologies, it is most often future generations who bear most risks. Risk analysis therefore becomes a delicate issue, because future risks often cannot be assigned a meaningful occurance probability. This paper argues that technology assessement most often deal with uncertainty and ignorance rather than risk when we include future generations into our ethical, political or juridal thinking. This has serious implications as probabilistic decision approaches are not applicable anymore. I contend that a virtue ethical approach in which dianoetic virtues play a central role may supplement a welfare based ethics in order to overcome the difficulties in dealing with uncertainty and ignorance in technology assessement.
Keywords: technology assessment, climate change, ethics, risk, uncertainty, virtue, expected utility, decision theory, intergenerational justice

`Prognoses are always uncertain – especially when concerning the future.' This statement attributed to W.Churchill expresses a difficulty central to all ethical theory seeking an implementation of its normative theories in moral practice. Decision making in general takes place under conditions of `uncertainty'.[1] The further the consequences of a decision[2] reach in time, the less the moral agent is able to anticipate the aftermath of this decision. Moral dilemmas, where obligations towards fellow human beings collide with obligations to prevent damage to future generations that might be very severe but whose probability of occurrence is presumably very low, pose a major challenge to any future ethics. Here many decisions under `uncertainty' cannot be transformed into certain decisions. Ethical reasoning has for the most part referred to a world in which morally relevant properties of human actions are certain in the sense that they are both well-determined and knowable. But the `uncertainty' of future damage is not something trivially added to the moral exercise, and cannot be treated as a mere technical complication relevant only when applying an ethical theory to actual problems.

At a first glance, two problems can be distinguished when dealing with the problem of `uncertainty' in a future ethics. The first, preliminary one is concerned with how the moral obligations towards futurity are affected by the fact that the existence of future generations as

[1] `Uncertainty' in inverted commas denotes the colloquial use of the term; a more technical definition is given later in the text. .
[2] Regarding non-acting as a kind of action, we do not distinguish between the terms `action' and `decision', the central term in individual and social choice theory, as any conscious action is preceded by a decision.

well as their preferred way of living are uncertain to the moral subject (section I). The second question asks, – presupposing some moral obligation towards future generations – how ethical reasoning and moral norms have to be modified in order to be able to cope with `uncertainties' which are inevitably related to the decision situation. Analyzing the term `uncertainty' in more detail (section II), we identify two major problems for ethical reasoning entailed in the second question. These are the incertitude with respect to the consequences of a decision (section III) and the incertitude when concerning the demarcation of a decision (section IV). It will be argued, that both types of `uncertainties', although closely interrelated, demand a different treatment. We conclude with a final summary (section IV). [3]

I. Moral obligations in the light of `uncertainty'

The question how moral norms have to be altered in order to apply `uncertain' decision situations shall be addressed in the proceeding sections. There a moral obligation towards future people will be presupposed. Before we are able to do this, we need to answer two preliminary questions that are addressed in subsection 1 and 2 respectively: Does the `uncertainty' affect the moral obligations we have towards futurity? Are certain moral concepts per se unable to cope with `uncertainty'?

1. Unknown number of future generations

At first glance, impartiality in the context of a future ethics seems to imply a zero discount rate and thus might yield serious difficulties: The fulfilment of the (basic) needs of presently living people quite often touches on exhaustible resources. Assuming that future people have, at least to some extent, the same needs as present ones, we are facing a dilemma: We have to spare some resources for futurity, but it is not clear how many. Assuming, for a moment, that no substitutes can be generated, then if the number of future generations is indeed infinite and we assume zero discounting, no generation is allowed to touch on these resources. That, in turn, makes the resources useless for any generation. If the number of future generations is equal to some finite value N, under the assumption of a zero discount rate every generation is allowed to exploit only 1/Nth of the original resources.

Before touching the issue of uncertainty, we want to stress, that the debate on discounting as it can be found mainly in economics literature has quite often not the relevance for ethical

[3] With respect to the complexity of the problem of `uncertainty' in the context of a future ethics, this article can neither yield definite solutions for the various problems it touches, nor can it give an exhaustive insight into all attempts proposed to treat the problems. Rather it aims at a systematic overview of problems and possible solutions.

reasoning with which it is sometimes credited. An investigation of the discounting rate debate is very fruitful on its own. But as it is a topic on its own, which is in most parts not related to the issue of `uncertainty', we only briefly touch on it as far as it relates to our topic. It has to be kept in mind that the term discounting as it is used, for example, in economics, does not correspond to discounting in moral theory.[4] To be more explicit, when dealing with discounting, we have to distinguish (a) arguments for impartiality on *moral* grounds from (b) a *pragmatic* argumentation for or against a discounting of future gains or losses. Such a pragmatic discounting is justified by the factual assertiveness of political guidelines.[5] Furthermore, (c) the discounting due to *diminishing marginal utility* as it is widely used in economics and (d) a discounting of *future market values* have to be distinguished from ethical arguments that give rise to impartiality. While the discounting of the diminishing marginal utility can be justified by psychological assumptions of the decreasing satiability of goods due to increasing avaiability, the discounting of future market values is the result of certain assumptions about the evolution of the actual interest rate and of the growth rate of the economy.[6]

Although considerations made, for example, about discounting in economy might to some extend be of use for ethical considerations and vice versa, the four kinds of discounting are clearly to be distinguished. Thus, the first impression as it was outlined at the beginning of this subsection might be misleading: Various aspects arising in (c) and (d) might justify a positive discounting of goods and market values, but this is not necessarily in contradiction to impartiality between generations.

In reality, the moral agent has no definite information on the actual number N of how many future generations will actually exist. So he does not even know how much he should, on moral grounds, save for future people. Does this affect his moral obligation towards futurity? This question was addressed by Dasgupta and Heal in the framework of decision theory.[7] Dasgupta's and Heal's argumentation is based on the assignment of some subjective probability[8] to the number N of existing future generations, that is: We assign a finite

[4] Birnbacher, Dieter, Brudermüller, Gert, Zukunftsverantwortung und Generationensolidarität, 2001, 117-136
[5] Lind, Robert C., Reassessing the Government's Discount Rate Policy in the Light of New Theory and Data in a World Economy with a High Degree of Capital Mobility, *Journal of Environmental Economics and Management* 18 (1990), 24
[6] Birnbacher, Dieter, Brudermüller, Gert, Zukunftsverantwortung und Generationensolidarität, 2001, 122, 129-132
[7] Dasgupta, P.S., Heal, G.M., Economic theory and exhaustible resources, 1995
[8] In this article the term `probability theory' is reserved for a formal account like the one given by Kolmogorov in 1931. Therefore we distinguish the (axiomatic) *probability* p from a measurable *frequency* p_N which is determined via N repetitions of the same setting (e.g. tossing of a coin) in real experiments or numerical simulations. Furthermore, a *subjective probability* ρ acts as a more or less sophisticated guess of p in cases where frequency approximations are not available or very unreliable.

probability $\rho^{(N)}$ to the extinction of mankind after N generations. The authors argued that a $\rho^{(N)}$ different from zero gives, under some additional assumptions, rise to a positive pure discount rate. These assumptions are very far reaching - a summary of the criticism on Dasgupta's and Heal's derivation can be found in Ponthiere.[9] Of course, rejecting Dasgupta's and Heal's derivation cannot put an end to the debate on discounting. But we want to point out that the discounting debate as it is based on the possible extinction of mankind after some unknown number of generations, quite often lacks implications for real life situations. Take, as an example, problems connected to the finiteness of our petroleum resources or the radiation risks from radioactive waste products. According to present knowledge, our petroleum supplies will last for approximately another 50 years if the present consumption is extrapolated, while for example Plutonium in radioactive waste products has a half life of about 25 thousand years and thus constitutes a major threat for human beings for roughly the same order of magnitude. Bearing in mind that the oldest fossils are attributed to (biological moderne) man are 160 thousand years old, and that other species such as some dinosaurs lived for around 50 million years, these time spans seem too short to sensibly assign a probability different from zero to the extinction of mankind within this time. According to these values it is not to be expected that the discounting debate based on a finite probability for the extinction of mankind leads, at least for the urgent problems in place, to any other results as when deciding upon a zero discount rate. Thus the discussion about discounting in the light of an `uncertain' number of future generations seems academic.

2. Uncertain preferences of future people

Setting aside the problem of discounting does not help us to get rid of the dilemma as it was described at the beginning of the proceeding subsection. It might be that, as in the case of petroleum reserves, saving an equal amount even for a very small number N of future generations, the resources left over for any generations are too few as to fulfill their needs. Thus, within a discussion on moral grounds where we want to stick to the maxime of impartiality, the problem we face is a real moral dilemma and we need to treat it as such.

Resolving such moral dilemmas seems to be a central issue of any future ethics. With respect to balancing the various obligations it has been argued by various authors that consequentialist approaches are superior to others.[10] In particular, welfare-based approaches

[9] Ponthiere, Gregory, Should we Discount Future Generations' Welfare? A Survey on the 'Pure' Discounting Rate Debate, CREPP Working Paper, 2003

[10] Patzig, Günther, Der Unterschied zwischen subjektiven und objektiven Interessen und seine Bedeutung für die Ethik, in: *Gesammelte Schriften 1*, ed. Günther Patzig, 1994, 80.

seem at a first glance to be particularly well suited to coping with moral dilemmas in the context of a future ehics.[11] Nonetheless, welfare-based approaches such as classical utilitarianism or preferential utilitarianism, that take into account (at least in principle) all the preferences of the people a specific decision touches on, face serious problems in the context of a future ethics. People's preferences are determined by a variety of circumstances – such as the natural environment, technical developments, and the structure of society. Thus influencing the preferences of future people or determining them on basis of (sophisticated) estimates on future people's living conditions, is only possible if at all, in a very restricted way.

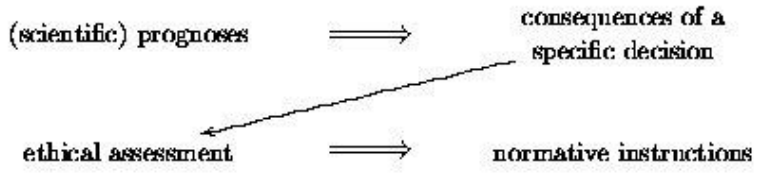

Fig. 1: Derivation of normative instructions. "=>" reads `yields as output', ``→" reads `is used as input for'. Note that on *both* levels `uncertainties' may enter.

In a consequentialist approach, moral reasoning has, given a specific scenario[12], to evaluate the consequences of a specific decision. The consequences entail `uncertainties' due to the prognosis they are based on. In an ethical assessment based on welfare approaches, additional `uncertainties' come into play because future people's preferences are not known in detail. These kind of `uncertainties' introduced on the last level in fig.1 have to be clearly distinguished from the ones on the upper level, introduced by the prognoses on the actual outcomes of a decision which are subject of a latter section: While we can discuss the question of how to react to the latter within the framework of some ethical theory, the `uncertainty' that enters on the level of ethical assessment itself might make the whole concept of a welfare based approach inconsistent: It is not clear how we can satisfy Bentham's principle `Everybody to count for one and nobody for more than one',[13] that is, how to take into account the preferences of all persons, future as well as present, in the same way, while

[11] For example, according to the reasoning of the authors mentioned in the main body of the text, welfarism is based on fewer premises than other consequentialist approaches. In the context of a future ethics it is advantageous to keep the number of premises used to derive moral norms low, as we can expect that the higher the number of premises, the fewer generations are able to agree on these norms.
[12] A definition of `scenario' is given in section II.
[13] Harrison, Ross 1993, *Democracy*, London/New York, 177.

on the one hand we know (at least to some extend) the preferences of presently living people, while on the other hand, the detailed preferences of future people are in principle unknown.[14]

The question of how to determine the preferences that have to be taken into account in welfare-based ethics is highly under debate even in an intragenerational context. Nonetheless, the problem becomes significantly more severe in the context of a future ethics as the uncertainties on future people's preferences increase with time. A proposed way of how to determine the preferences relevant for ethical reasoning that can be extended straightforwardly from the intra- to the intergenerational case was originally proposed by J.St.Mill: The preferences relevant for ethical assessment are identified with the ones which an omniscient and experienced person would have. This approach, however, has been argued to be circular or to yield an infinite regress. Other suggestions of how to determine preferences relevant for ethical assessment, such as the ones based on representative opinion polls as suggested by G.Patzig, cannot be extended to a future ethics.[15]

If we nevertheless want to obey Bentham's principle of procedural equality, the preferences taken into account in moral reasoning have to restrict to those which are basic in that sense that (a) *all* human beings as such share them and (b) their fulfillment is a *necessary* condition for living an (according to individual criteria) good life – such as the need for sleep, nutrition or some kind of security. A similar argumentation was given by J.Rawls in an intragenerational ethics: When choosing a constitution, the preferences taken into account have to restrict to interests in so-called `primary goods' which obey (a) and (b).[16] In accordance with Rawls we hold the opinion that the primary interests are not merely restricted to physical interest aimed purely at the maintenance of live. But we do not follow Rawls' determination of `primary goods' in context: It has been argued in the literature that Rawls' `primary goods' are not invariant under different economical and social systems und thus interests in these `primary goods' do not obey (a) and (b).[17] The criticism raised against Rawls holds also for the extension of his theory of justice to intergenerational ethics, as it is done by B.Singer.[18]

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[14] Further problems that utilitarian ethics face in the context of a future ethics when the number of generations tends to infinity, but which are not primarily related to `uncertainty' are discussed in Liedekerke/Lauwers (1997) and in Lauwers/Vallentyne (2004).

[15] Patzig, Günther, Der Unterschied zwischen subjektiven und objektiven Interessen und seine Bedeutung für die Ethik, in: *Gesammelte Schriften 1,* ed. Günther Patzig, 1994, 93

[16] Rawls John, Social Unity and Primary Goods, in: *Utility and Beyond,* ed. A. K. Sen, B. Williams, 1982, 161

[17] See e.g. De-Shalit, Avner, Contractarian Theories of Intergenerational Justice, in: *Why Posterity Matters. Environmental Policies und Future Generations,* ed. A. De-Shalit., 1995, 102f. as one of many authors involved in this field.

[18] Singer, Brent A., An Extension of Rawls' Theory of Justice to Environmental Ethics, *Environment Ethics* 10(3) (1988), 217-231

The reduction of the preferences which have to be taken into account in ethical reasoning on such basic or primary interests which are the necessary prerequisites for any human being to be able to live a, according to individual criteria, `good' life, implies that the present generation as well as future ones have to accept a cut in their standard of living: For example, even known preferences of present people cannot be taken into account in order not to violate the principle of procedural equality.[19]

II. Incorporating `uncertainties' in ethical reasoning

For the remainder of the article we assume a moral obligation to take into account the needs of future people in the same way as the needs of our fellow human beings. But raising the question on the morally right behaviour under `uncertainty' in the demotic meaning of the word resembles opening Pandora's box. An analysis of the colloquial use of the term `uncertainty' shall make it accessible to a systematic treatment (2.1). The different kinds of `uncertainties' we will identify are illustrated at a specific example, the man-made greenhouse effect (2.2).[20]

1. A typology of `uncertainty'

The following classification of `uncertainty' with regard to context follows loosely Hansson 1996 and distinguishes three kinds of `uncertainties', namely `incertitude of consequences', `incertitude of demarcation', and `incertitude of reliability'.

Incertitude of consequences: Quite often the outcomes of the various decision options are not clear to the decision maker. This might be due to the fact that information which might influence the knowledge of consequences of a decision is not available or is on such a scale that it cannot be assessed adequately by the agent within the time the decision has to be taken. This can be due to (i) contingent features of the specific situation. But there may also be (ii) limitations in principle to obtaining such information: The future course of environment, societies, technologies, etc., is to a large extent unknown to the moral subject at the time of the decision, but will also codetermine its consequences. Furthermore there are situations where (iii) the decision touches systems that do not allow for certain predictions: Complex systems as the climate system or sociological systems entail feedback processes and therefore – although the underlying dynamics is purely deterministic – cannot be predicted with

[19] The problems related to the excessive demands of utilitarian approaches in the context of a future ethics are thus not resolved by restricting the morally relevant preferences to those that are ‘basic’.

[20] In accordance with the technical literature, the term `greenhouse effect' refers to the fact that due to the existence of so-called (natural and man-made) greenhouse gases in the troposphere, there is less thermal radiation retransmitted from Earth into space.

certainty as they *might* exhibit chaotic behaviour. At least with respect to (ii) and (iii), the higher the predicted time scale, the higher are the incertitudes related to that prognosis. Thus the incertitude of consequences constitutes a severe problem in particular in the context of a future ethics.

Incertitude of demarcation: Any analysis of a specific decision must start with some demarcation of the decision itself. Facing actual decisions, the incertitude of demarcation can be twofold: (i) Assuming the general purpose of the decision is well determined, it can still be unclear whether all the available options have been identified. As for the incertitude of consequences, this constitutes a problem in principle as for many decisions future research might find new ways of how to act. Thus one can never be sure to have identified all the possible decision options. Furthermore, (ii) not in every decision situation is it established how to determine the `decision horizon'[21]: The scope of the decision or even which problem the decision is supposed to solve might be unclear. Using natural language with all its counterfactual assertions that refer to future and past events, the various options of how to decide in a given situation are such that `a person has only one decision to make in his whole life. He must, namely, decide how to live, and this he might in principle do once and for all'.[22] Hence the actual decision horizon would be infinite. Nevertheless, in order to be able to make any decision, one has to restrict the decision horizon. The further in time the consequences of our decisions lie, the higher is the incertitude of demarcation. This second incertitude of consequences as well cannot be eliminated in principle, as any decision has to be taken in a finite amount of time. Thus in the field of (applied) ethical reasoning we are always confronted with the question as how to determine the decision horizon – not because there is a moral reason for treating different people in a different way (this argument was indeed subject of section I), but simply because they cannot be treated in the same way due to features of the decision situation itself.

Incertitude of reliance: In many cases it is not clear, if the available information which is necessary to determine the consequences, the available options, as well as the horizon of a certain decision is at all reliable. It might be difficult or even impossible for the moral subject to determine whether the people providing it are themselves reliable, whether the used methodology is subject to doubt, or even how to determine the relevant scientists for obtaining the information. This is a severe problem especially when we are concerned with

[21] Hansson, Sven O., Decision Making under Great Uncertainty, *Philosophy of Social Science* 26(3) (1996), 371
[22] Savage, Leonard J., The Foundations of Statistics, 1954, 83

the remote future: Modern techniques and technologies have significantly raised our ability to influence the living conditions in the remote future. Therefore, `uncertainties' of the prognosis quite often arise when concerning a morally adequate relationship to modern technics and technologies. Here the moral agents crucially depend on the information given by experts.

How to deal with the various incertitudes identified here – how to take into account of the uncertain consequences of a decision, how to deal with an unfinished list of decision options as well as with a finite decision horizon, and how to estimate the reliability of the available data - constitute major challenges for ethical reasoning in the context of a future ethics.

2. `Uncertain' decisions: an example

Before proceeding further we want to illustrate the three types of incertitudes and their interrelation by the morally relevant problems arising from man-made emissions of greenhouse gases. Firstly, we focus on the origin of the incertitude of *consequences*. Most of the time, prognoses that policy makers, for example, face when dealing with `uncertain' impacts of present-day actions on future generations are the results of rather complicated analyses. The arising of incertitudes of consequences is illustrated in fig.2 for the greenhouse effect. In a similar fashion this scheme can be extended to other prognoses on the long-term effects of present actions. Concerning our example, the consequences of an enhanced greenhouse effect due to man-made emissions of greenhouse gases are largely unclear. Possible aftermaths range from a severe global warming through hardly any changes to a cooling down of parts of the globe. This incertitude is due to shortcomings of present climate models as well as to the fact that the climate system entails feedback processes (middle plane in fig.2). Further `uncertainties' about future energy-, socio-, and economic-political decisions estimated in so-called `energy scenarios' (upper plane) enter in prognoses on the future climate. The mere fact that there is a rise in the average annual temperature, as climate models might indicate, is of no use for an ethical investigation of actions releasing greenhouse gases. Important for ethics are the implications of such climate changes for the natural environment (such as a rise in sea level) and its consequences for future people (e.g. via changed cultivation conditions for crops). Via so-called `impact models' which estimate these implications (third plane in fig.2) additional incertitudes of consequences come into play.[23] Between the various levels there are feedback processes, which are very hard to take into consideration.

[23] Nordhaus, William D., Boyer, Joseph, Requiem for Kyoto: an economic analysis of the Kyoto protocol, *The Energy Journal*, Special Issue (1999), 93-130

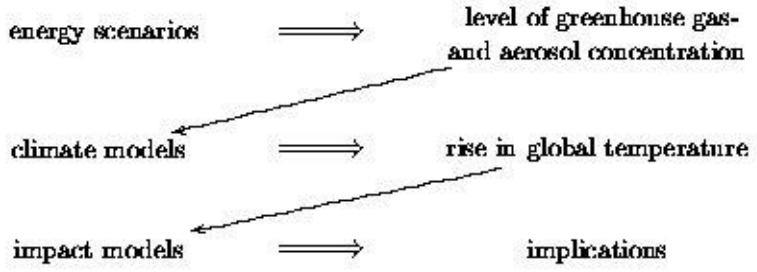

Fig. 2: Estimation of consequences of man-made emissions of greenhouse gases (following Schönwiese/Diekmann 1989). For an explanation of the symbols, see fig. 1.

Concerning the incertitude of *demarcation,* we note that it seems to be a general feature that various interest groups have different opinions on the decision horizon. It is under debate as to whether a possibly man-made climate change can be discussed independently of problems connected to the use of energy resources whose usage emits no greenhouse gases, such as nuclear power. Discussing nuclear waste disposal, one might ask whether we do or do not have to take into account that future generations might be incapable of reading records on the waste disposal while, at the same time, there will have been no other information transfer from one generation to the next on the subject of nuclear waste disposal. We can continue with an infinite list of related questions. Concerning the first kind of incertitude of demarcation as it shows up in connection with a man-made greenhouse effect, we note that it is not at all clear whether there are yet unknown means as to how to compensate for or adapt to (severe) climate changes.

The problem the moral agent encounters when estimating the *reliability* of the information needed for the ethical evaluation of the forecasts given on the last plane in fig.2, is expressed lucidly by the German Umweltbundesamt which states (Umweltbundesamt 2003, my translation): `Concerning the present climate debate the layman seems to be incapable of judging whether a report really emanates from a research with adequate quality standards or if it represents only some ``story''.' Present climate models are not well established, and especially the methodology used in impact models – for example the monetarization of `utility' in so-called Willingness-to-Pay approaches as they are used by Nordhaus and Boyer[24] - is subject to doubt. Not only for the greenhouse effect, but for many prognoses relevant in the factual political decision making process, prognoses on the long-term impacts of decisions comprise the forecasts of scientists in various fields. The scientists working on the different

[24] Nordhaus, William D., Boyer, Joseph, Requiem for Kyoto: an economic analysis of the Kyoto protocol, *The Energy Journal*, Special Issue (1999), 93-130

`levels' have to rely crucially on the data of the preceding plane. As cooperation is rare between scientists working on different levels and in general a common terminology is missing, it might be very hard even for the scientist himself to assess the reliability of his `own' data.

III. The applicability of decision theory

Proceeding further by closing Pandora's box, we begin the investigation of how the problem of `uncertainties' can be treated within ethical reasoning concerned with future generations

by restricting to the incertitude of consequences. Acting on a suggestion already given by F.H.Knight in his classical book on `uncertainty', we specify the incertitude of consequences according to its `degree' (3.1).[25] The incertitude of consequences is treated systematically in the framework of decision theory and risk analysis.[26] By means of two paradigmatic models of decision theory it shall be discussed, if and how such models can be used as a tool in moral philosophy concerning the remote future for actions under risk (3.2), uncertainty (3.3), and ignorance (3.4).

1. `Uncertain' consequences - a classification

Following the nomenclature which is used in ethics of technology, we distinguish three different kinds of incertitude of consequences: *Risk* is defined as a setting in which all possible outcomes of the decision are known and can be assigned some frequency p_N which offers some confident estimate of the occurrence probability p of the corresponding outcome.[27] *Uncertainty* is defined by a setting in which again the whole set of outcomes is known but not for all outcomes can one assign the corresponding frequencies. Situations where one lacks knowledge not only on the probabilities, but on (part of) the outcomes too, are called decisions under *ignorance*. Due to the dominance of what is often referred to as `Bayesian theory' the distinction between the three cases, namely, decisions under risk, uncertainty and ignorance, was abandoned by many economists and philosophers. Yet the generality and simplicity of the Bayesian approach, which makes it popular in many fields, as well as the somewhat artificial boundary between decisions under risk, uncertainty, and

[25] Knight, Frank H., Risk, Uncertainty, and Profit, 1984, 19

[26] We do neither aim at an overview of the various, sophisticated models used in both fields, nor do we want to give an exhaustive insight into the various critiques raised against those. For reviews on decision theory see e.g. Jeffrey, Richard C., *The Logic of Decision*, 1983 or, for a non-mathematical introduction, Hansson, Sven O., Decision theory. A Brief introduction, 1994. Commemorating the discussion in section 1, the morally relevant preferences that determine the utilities relevant in the decision theoretical models are those that have been defined as 'basic'.

[27] Leitner, Rupert, Responsibility and uncertainty, *Newsletter. Akademie-Brief der Europäischen Akademie zur Erforschung wissenschaftlich-technischer Entwicklungen* 50 (2004), 1-3

ignorance, should not distract from the fact that this distinction is of great importance for *ethical* considerations. Therefore the terminology used in decision theory, that blurs the differences between a frequency and a subjectivist approach to probabilities (e. g. Luce/Raiffa 1957, 13), is inadequate for ethical reasoning.

Actual situations quite often entail elements of risk, uncertainty, and ignorance: There is a more or less continuous gradation of incertitudes of consequences running from the ideal case (choices under certainty) to complete ignorance. Classifying a certain decision situation as a situation under risk, uncertainty or ignorance, is somewhat arbitrary. Here the second kind of incertitude of demarcation comes into play: The wider the chosen decision horizon, for example, the more likely we face a decision under ignorance; narrowing down the decision horizon, we will encounter a risky situation. Although incertitude of consequences and of demarcation are thus interrelated, the two are conceptually different. In order to make the problem of `uncertainty' analyzable despite this interrelation of the incertitude of demarcation and the incertitude of consequences, we define the term `scenario' as a set of decision options where the classification to risk, uncertainty or ignorance is well determined.

2. Decisions under risk

Decision theory summarizes the various factors which determine the outcomes of a decision but which are not under the control of the agent in so-called `states of nature'. Concerning decisions under risk, each of these states can be assigned some definite frequency. One can distinguish roughly between two kinds of decision models: The first makes use of the approximations of the probabilities, which denote the likelihood of occurrence for the uncontrollable states of nature. The other approach, so-called `elementary decision theory models', makes no use of these probabilities. In 3.2.1 we discuss ` *E*xpected *U*tility *T*heory' (EUT) as a simple example for a probabilistic decision model, since a large number of models developed for decision making under risk and uncertainty can be regarded as variations or generalizations of EUT.[28] To exemplify an elementary decision model, we discuss in 3.2.2 the so-called maximin criterion, since this is a fairly popular approach in future ethics.

[28] e.g. Bell, David E., Regret in Decision Making under Uncertainty, *Operations Research*, 30 (1982), 961-981 // Kahneman, Damiel, Tversky, Amos, Prospect Theory: An Analysis of Decisions under Risk, in: *Decision, Probability, and Utility*, ed. P.Gärdenfors, N.-E. Sahlin, 1988, 183-214 // Loomes, Graham, Sugden, Robert, Regret Theory: An Alternative Theory of Rational Choice under certainty, *Economic Journal* 92 (1982), 805-824

a) Expected Utility Theory

In many fields dealing with risk or uncertainty analysis, EUT can be regarded as state of the art. The idea behind EUT is to extend the definition of rational decisions under certainty, where the objects of choice are the possible distributions $x^{(k)}$ of some commodities, to decisions where the outcomes are uncertain. In the latter case the objects of choice are identified as probabilities or `lotteries' over outcomes.[29] The outcomes themselves consist again in a distribution of commodities. In analogy to the certain case, a rational preference ranking of person i can be represented by a real valued preference function V_i depending on the probabilities p_k assigned by the lottery to the outcome of `winning' a specific distribution $x^{(k)}$. Denoting with $u_k$ the `utility' that person i gets when the outcome $x^{(k)}$ of the lottery occurs, EUT assumes that the individual preference function is given by the expectation value of the `utilities' u_k,

$$V_i(p) = \Sigma_k \, u_k \, p_k \, . \qquad (1)$$

Hence the name `expected utility theory'. As in the certain case a `rational' individuum is modelled as if trying to maximize the value of $V_i(p)$ over the currently available set P of possible lotteries.

In order to make the transition from individual to social choice theory, one might follow J. Harsanyi's approach[30] that implies that the overall social welfare function W(p) is given by a linear function of the individuals' personal preference functions $V_i(p)$:

$$W(p) = \Sigma_i \, V_i \, (p) \, . \qquad (2)$$

According to Harsanyi, morally correct behaviour maximizes the thus obtained W over a given P. Assuming the number of individuals in eqn. (2) to be fixed, the overall social welfare function for lotteries is given by the arithmetic mean of the individuals' welfare functions $V_i(p)$ just as for classical utilitarian theories in the certain case.

[29] Luce, Duncan R., Raiffa, Howard, Games and decisions, 1957, 24

[30] Harsanyi, John C., Cardinal Utility in Welfare Economics and in the Theory of Risk-Ranking, *Journal of Political Economy* 61 (1953), 434 / Harsanyi, John C., Cardinal Welfare, Individualistic Ethics and Interpersonal Comparison of Utility, *Journal of Political Economy* 63 (1955), 309-321 / Harsanyi, John C., Nonlinear Social Welfare Functions", *Theory and Decision* 6 (1975), 311-332

In order to analyze the applicability of EUT to problems encountered in a future ethics, let us focus only on the personal preference function, leaving ethical arguments apart for the moment and consider solely the `rationality' of the expected utility approach.

Adequacy of probabilistic models: [31] Concerning any probabilistic decision model it has been argued that decisions might not be irrational even when they contradict the model.[32] For example, nuclear physics can on a probabilistic basis determine the time after which half of a given probe has decayed only if the probe contains a *sufficiently large* number of nuclei. It is not possible to make any forecast on the behaviour of one or a few specific nuclei. Just the same, a probabilistic decision model has to assume that the decision under consideration is repeated sufficiently often: Assuming we have a reliable probabilistic decision model suitable for a specific problem, then acting against it could be regarded as irrational when the same decision is taken many times. But decisions touching future generations are often political positions of points taken only once. This is the case when deciding about the permitted amount of CFC or greenhouse gas emissions, the permission of experiments in the field with genetically modified plants, etc.

Adequacy of EUT: Concentrating on the long-term effects of a decision, we want to add a critique on the functional form of the individual's preference function as it is supposed by EUT in equation (1). Although at a first glance it might seem reasonable to base decisions on the expectation value of the utility, this is indeed not the case, at least not for decision under risk:[33] Probability densities yielding the same expectation value may have very different probabilities for the occurrence of `extreme' events far away from the mean for example. As a simple example we consider a case in which personal well-being is directly (negatively) correlated to the (rare) occurrence of wind gusts, where the wind speed changes rapidly over a small time interval. If the underlying probability density of changes of wind speed over a

[31] The argument as it is sketched in the text holds only for a frequentist's interpretation of probabilities. It is basically a reformulation of the so-called `central limit theorem'. It states averaging long enough – for example, taking large time averages – yields *on average* a measured value equal to the mean. A single measurement however is not necessarily equal to the mean even when the central limit theorem holds. The criticism concerning the applicability of EUT (see main text below), shows that indeed in many cases the central limit theorem is not even applicable and even when considering large averages we might have, on average, deviations from the mean.

[32] Hansson, Sven O., Ethical criteria of risk acceptance, *Erkenntnis*, 59 (2003), 291-309 / Hansson, Sven O., What is philosophy of risk?, *Theoria*.62 (1996), 169-186
Hansson, Sven O., Decision Making under Great Uncertainty, *Philosophy of Social Science* 26(3) (1996), 369-386 / Hansson, Sven O., The False Promise of Risk Analysis, *Ratio* 6 (1993), 16-26 // Agarwala, B.K., In Defence of the Use of Maximin Principle of Choice under Uncertainty in Rawls' Original Position, *Indian Philosophical Quarterly* 8(2), (1986) 169

[33] In our analysis we assume for simplicity a continuous distribution of commodities. The transition to a discrete distribution as it is used in equation (1) is straightforward.

fixed time interval were Gaussian with the same mean as the actual density, the gusts that are actually measured every hour would be expected to occur once a century.[34] An individual welfare function that restricts itself to the expected utility seems insufficient since it does not distinguish between these two cases. In general, many decisions touch on complex systems and in particular their long-term consequences are determined by their effects on the evolution of these systems. Recent investigations of such complex systems – ranging from geophysical data, like frequencies of wind gusts, earthquakes, or flood disasters, to many financial data like price changes in some time interval – reveal the importance of taking into account the full form of the probability density, that is, not only its first moment like in EUT, but all higher moments as well have to be considered. The importance of taking into account the full probability density becomes more pronounced when long-time periods are considered: If the underlying limiting probability density is non-Gaussian as it is, for example, in the case of the occurence of wind gusts, then the more often a stochastic event occurs (e.g. when taking longer time averages), the more frequently extreme events that deviate from the mean occur. Thus deviations form Gaussian limiting distributions become particular important with regards to the remote future.[35]

Moral objections: Taking the individual's personal and social preference functions to be linear in p, has been criticized in this article for being unable to treat the complexity of many decisions adequately. In the past, the linearity of the social preference function has been subject to a lot of attacks based on moral grounds as well - not to mention the important contributions of Diamond and Sen here.[36] It has been argued that the linearity of the social preference function is in contradiction with some sentiment of justice of moral subjects.[37] Theses critiques aimed mainly at undermining the specific form of W. We do not want to go into detail on that discussion and the proposed solutions, since these are not specific for decision under `uncertainty'. In fact, they contribute mainly to the general discussion on

[34] Böttcher, F., Barth. S., Peinke,J., Stoch. Environ. Res. Risk Assess. 21, 299 (2007).
[35] There are various approaches discussed mainly in the framework of Bayesianism that qualify as such decision models taking into account higher moments and that can be extended to decisions under risk as they are defined here. See, for example, Campbell, H.R., Liechty, J., Liechty, M.W., Mueller, P., Portfolio selection with higher order moments, 2004 and references therein. But neither for probability densities for which the second or even the first moment does not exist nor for intermittent distributions, there exists at present a satisfactory decision models. As these probability densities seem to appear rather often, this is an open problem presently discussed in the so-called `Fat Tail'-community (e.g. Embrechts/Klüppelberg/Mikosch 2001).
[36] Diamond, Peter A., Cardinal Welfare, Individualistic Ethics, and Interpersonal Comparison of Utility: Comment, *Journal of Political Economy* 75 (1967), 765-766 // Sen, Amartya, Rationality and Uncertainty, *Theory and Decision* 18 (1985), 109-127
[37] Diamond, Peter A., Cardinal Welfare, Individualistic Ethics, and Interpersonal Comparison of Utility: Comment, *Journal of Political Economy* 75 (1967), 765

distributional justice.[38] But taking into account that a decision function based solely on the expectation value is inadequate for individual decisions, it does not qualify as a basis for the derivation of a social decision function.

b) Maximin strategy

As an example for an elementary, which is non-probabilistic decision model, we will discuss the maximin model. According to maximin, for all decision options one shall choose the worst possible outcome and settle for the decision that yields the best of these worst options, that is: *Maxi*mize the *min*imal utility that one obtains when the worst case occurs. For social choice in the context of future ethics, the optimal decision according to maximin was formulated most strikingly by H. Jonas: `The prophecy of doom must take priority over the prophecy of bliss.'[39]

For decisions under risk, maximin neglects a lot of the available information. If the worst-case scenario is not due to happen, the outcome of the decision might be far from optimal. Take for example a disease that is likely to be caught with some very small probability p_0 and might with some finite, but very small probability p_1 lead to death. An available vaccination has the disadvantage that it yields with some rather large probability p_2 >> p_1 and p_2 >> p_0 to deafness. Maximin would settle for option of vaccination, but – looking at the way vaccinations against life-threatening diseases are actually administered in Europe – this is not the way people really act. Of course, empirical results on how people behave imply nothing about the rationality or the morally correctness of this behaviour. Nonetheless, such a discrepancy might indicate that the maxime is not in accordance with the moral intuition of rational individuals. Therefore, most authors who opt for maximin in the context of decision under risk, do so only when `the survival and humanity of man' is endangered by one of the possible decision outcomes. This is the case for Jonas[40] and for Birnbacher on the level of norms for real moral agents.[41] Jonas and Birnbacher settle for maximin for different reasons: For decisions under risk, Jonas would recur on a teleological interpretation of nature, while

[38] See, for example, the monograph edited by Allais and Hagen (1979).
[39] Jonas, Hans, The imperative of responsibility: In search of an ethics for the technological age, 1984, 255
[40] Jonas' paradigm is indeed not decision under risk, but decision under ignorance. But his argumentation for an `Imperative of Responsibility' is twofold: Jonas' *methodological* argumentation (see 3.3) - based on the fact that future course of technical inventions and scientific research cannot be predicted - does, of course, not apply in the contest of decision under risk. Nonetheless, Jonas' second, *metaphysical-religious* argument, as it is embraced in the main part of Jonas, Hans, The imperative of responsibility: In search of an ethics for the technological age, 1984 applies even to decisions under risk.
[41] These are the so-called `Praxisnormen' that parallel Hare's `second-level principles' or norms on an `intuitive level'.

Birnbacher argues for an `heuristic of fear' because real addressees of moral norm have cognitive as well as motivational deficits.[42] But even with this restriction to decisions where the existence of human kind is endangered, maximin as a guiding rule for decisions under risk faces serious problems.

Moral dilemmas: Maximin is not able to treat all moral dilemmas that appear in a future ethics. One might have to decide between two policies, both of them yielding the same cardinal harm, but with significantly different probabilities. For example, settling for any of these policies leads with finite probability to the extinction of man. On the basis of maximin alone, we cannot decide whether to settle for the option where the probability of extinction is much lower than in the other or not.

Consistency: The `worst case' might be determined not only by the threat of harm on (future) people, but also by the number of people who are harmed. In decisions under risk the latter might be codetermined by the probabilities associated with that event. Under such circumstances a non-probabilistic decision model is not only unsatisfactory, it is even not consistent. Imagine we have the choice between two energy policies, one settling for the use of nuclear power plants, the other uses conventional forms of energy. [43] The first decision option has the disadvantage that with some finite probability p_0 there will be a major leak of nuclear radiation. This leads with p_1 to the death of a person located at some distance from the power plant. In the second case, we have a probability q_0 that our policy leads to global warming which has the consequence that with q_1 a person will die. The number of people who will die, can only be predicted in terms of probabilities: The probability that N people die is given by $p_0\ p_1^N$ in the first, by $q_0\ q_1^N$ in the second case. Thus if $p_0 >> q_0$ and p_1 and q_1 are of the same order of magnitude, it is highly likely that in the second case more people will die. Although the situation as it was outlined here is by no means related to any real life decision situation, the example shows that probabilities are indeed of importance for ethical reasoning – one reason being that probabilities (co-)determine the strength of the harm. For simplicity we compared decisions, which worst outcomes lead to the same harm. For welfare-based theories in which the strength of individual harm and the number of people harmed can be

[42] Birnbacher, Dieter, Verantwortung für zukünftige Generationen, 1988, 204
[43] This example is indeed too simplified to reflect by any means the problem encountered in energy politics as in particular we are still discussing decisions under risk.

offset against each other via an extremal principle, the extension to situations in which the individual harm differs is straightforward.[44]

Number of Premises: Furthermore, maximin can be understood as the decision criterion of an overly pessimistic actor who is averse to large losses and is willing to forgo attractive gains in order to avoid large risks. In situations in which decision maker and people affected by the consequences of the decision differ, as it is the case when we are concerned with the effects on future generations, the maximin criterion has to make, compared to EUT, additional assumptions on other people's preferences, that is it assumes for example that future generations are overly risk averse.[45] Nonetheless, extreme risk aversion as well as extremely risky behaviour do not seem to be preferences shared by all people in the same way.

According to the preceding analysis, we hold the opinion that for decisions under risk a probabilistic account is more suitable – even when one of the decision outcomes endangers the future existence of human beings. The main argument in favor of a probabilistic account is based on the fact that determining the worst case scenario seems to depend on the numerical values not only of the expected harm. But the numerical values of the frequency estimates for the occurrence probabilities of this harm are relevant as well because they may relate to the `strength' of the harm, e.g. as they codetermine the number of people harmed. Concerning the special form of the probabilistic decision model, we argued that especially when we consider long time averages, extreme events far away from the mean might occur rather often. The information about how often is entailed in the higher moments.

3. Decisions under uncertainty

In order to make any probabilistic decision model fruitful for decisions under uncertainty, one has to assign `subjective' or `personal' probabilities to those outcomes for which frequencies are not known. Such a `closure ansatz' is often referred to as `Bayesian approach'. More sophisticated approaches reintroduce in a second step uncertainty into a closure ansatz: So-called `second level subjective probabilities' or `higher order beliefs' estimate the reliability of the assessed occurrence probability of the various outcomes.

At first glance, maximin seems to be well suited for decisions under uncertainty: It can be applied without introducing additional information in the form of subjective probabilities. Therefore, no matter what the expected harm, even authors who prefer EUT for decisions

[44] We only want to mention that there might be severe problems related to the assumptionof cardinal harms and utilities.

[45] The same criticism applies as well to optimist decision rules or even to the Hurwizc decision rule.

under risk, settle for maximin for decisions under uncertainty.[46] Nevertheless, as for decisions under risk, maximin neglects available data: (i) In many decisions one cannot assign frequencies to all outcomes, but at least to some. (ii) There might be subjective probabilities `reliable' enough to be taken into account in moral considerations.

Relevance of probabilities: With respect to the first criticism, imagine, for example, the situation where a new drug is the only means against a global epidemic which yields to death of a large fraction of the word's population with some rather high probability known via frequency estimates. The drug has not yet been tested extensively enough for side effects and it cannot be ruled out on the basis of numerical or experimental measurements that the drug, for example, causes a change in DNA which might in the long run constitute a major threat for the existence of mankind. Maximin forbids the launch of the drug as the extinction of mankind constitutes a bigger harm than the extinction of only a large part of it. But one can still argue, that, nonetheless, it might be better to release the drug as the possibility for the worst case scenario might in the end be very low. And thus risking the death of so many people, that could be saved with rather large probability, seems not to be justifiable. It would appear that moral philosophy cannot focus only on the harm of the worst outcome. Rather it seems that the strength of the harms of other decision outcomes as well as the numerical values of the known probability estimates are relevant for ethical reasoning.

Frequencies versus subjective probabilities – Incertitude of reliability: Concerning the second criticism, it shall be pointed out that an overall preference of frequencies to subjective probabilities does not seem adequate in many cases. We deliberately did not follow the terminology used in risk analysis and decision theory where frequencies p_N are termed `objective' probability. The term frequency is less misleading as there might be too little data or the experimental or numerical setting used to determine the frequencies is too simplified in order to rely on the frequency approximation for real life situations. Present climate models which are incapable of incorporating most of the feedback processes between atmo-, hydro-, litho-, kryo-, and biosphere are a paradigmatic example for the latter. Here frequencies given by numerical simulations that make use of oversimplified models might be less reliable than an ad-hoc guess of a specialist who might have, during the time he has been working on the field, developed an intuitive understanding of how such systems can react. It is crucial for

[46] e.g. Birnbacher, Dieter, Verantwortung für zukünftige Generationen, 1988, 154

moral philosophy to distinguish between a sophisticated guess by experts and, for example, the assumption of uniform probability due to J. Bernoulli's principle of insufficient reason.

Although frequencies and subjective probabilities differ ontologically, they are treated technically in the same way. It is up to moral philosophy to reason about a kind of `threshold' indicating when to make a `closure approach', that is, when to accept the subjective probability estimate and treat decisions under uncertainty in the same way as decisions under risk, and when to use maximin.[47] This threshold depends on the reliability of the subjective probability estimates which depends on many contextual features. The novelty of the methods used to assess the probabilities is relevant here: There are, for example, big differences in the reliability assessed to the `risk analysis' of nuclear power plants today and the first *Reactor Safety Study* of the U. S. Nuclear Regulatory Commission in 1975, the so-called WASH-1400 or Rasmussen report. The latter was subject to many epistemological and methodological doubts. Later reports incorporated at least some of the critique and thus are at least in some aspects more trustworthy than the original Rasmussen report. The evaluation of the reliability of information including information on probabilities is not primarily the subject of moral philosophy, but rather of epistemology and more applied ethical reasoning concerned with one specific problem and is thus not within the scope of this text.[48]

4. Decisions under ignorance

Contrary to decisions under risk and uncertainty, for decisions under ignorance we do not actually know all possible outcomes for every decision options. But in practice, at least for some decisions under ignorance one has the choice between some options of which all possible outcomes are known and others options of which they are (partly) unknown. This is Jonas' paradigm where his second, methodological argument of the `Imperative of Responsibility', namely the `Heuristic of Fear' comes into play.[49] Nonetheless, the maxim to

[47] For example, Rawls (Rawls, John, A Theory of Justice, 1999, 134) and Gardiner (Gardiner, Stephan M., A Core Precautionary Principle, *The Journal of Political Philosophy*, 2005) opt for maximin only if, in addition to other premises, there are no 'reliable' estimates of the probabilities. But it is not explicitly discussed by the authors, when a probability estimate can be accepted. It rather seems that both authors accept only frequency estimates. According to the analysis in themain text, this is not adequate in the context of a future ethics. In general, the term `ignorance' has to be distinguished clearly from the terminology used by Rawls as well as by Harsanyi and others in connection with investigations on distributional justice. While in our case `uncertainty' is a characteristic feature of real life situations, these authors use it for a normative construction. Furthermore it shall be noted that in our terminology Rawls' as well as Harsanyi's `veil of ignorance' establishes a situation under uncertainty, not under ignorance.

[48] The problem of incertitude of reliability was, for example, elaborated in great detail, although certainly not exhaustively in the form of the philosophical discussion about the nonmilitary use of nuclear power in the 1970s and 1980s (Thompson, Paul B., Uncertainty Arguments in environmental issues, *Environmental Ethics* 8 (1986), 59-75 // Shrader-Frechette, Kristin S., Nuclear Power and Public Policy, 1980)

[49] Jonas, Hans, The imperative of responsibility: In search of an ethics for the technological age, 1984, 9

avoid, if possible, any action with unknown outcomes because these might constitute a threat for the existence of mankind, yields severe consequences. As for example the future course of scientific research as well as of technical progress is often unpredictable, an overall application of this maxim yields a cessation of any scientific research that could be implemented in technical practice. Furthermore, when dealing with decision under ignorance, it is quite often the case that for more than one decision option not all outcomes are known. Just imagine being faced with the decision between two global energy polices – one invests in conventional energies, the other settles for energy saving measures. Via a possible change of climate the former option might have widely unknown consequences, while for the latter it might be argued that we cannot know all decision outcomes as we never faced the situation of a large and still growing world population and thus cannot estimate the aftermaths of a significant, global energy saving policy. Thus the maxime to avoid decisions whose outcomes are widely unknown cannot account for moral dilemmas as the show up in real life settings.

In order to apply any probabilistic or non-probabilistic decision model to situations under ignorance, we have to rely on a closure approach by making additional assumptions. (i) The simplest approach ignores unforeseen consequences. This does not seem to be adequate for many situations: In the 20th century, the use of new techniques and technologies provided examples that some actions lead to unforeseen consequences. The people who in the 1970s released CFCs on the market as excellent cleaning and cooling agents can hardly be made responsible for the consequences of this launch. Nowadays however we face a different situation: The experience with launching CFCs cannot be ignored and now we have to take into account that for example releasing new technical achievements might have unforeseen consequences. (ii) In cases like the one just mentioned, one might think of providing financial funds for unpredicted negative consequences occurring.[50] But problems arise when determining the amount of the financial reserves. (iii) A more sophisticated closure is frequently used in risk analysis: When for a scenario n possible outcomes of a specific decision are known, unforeseen consequences can be incorporated by assuming the existence of another (n+1)-st outcome which is not and cannot be specified any further.[51] This so-called `other scenario'[52] summarizes everything that was not taken into account in the first n

[50] e.g. Leitner, Rupert, Responsibility and uncertainty, *Newsletter. Akademie-Brief der Europäischen Akademie zur Erforschung wissenschaftlich-technischer Entwicklungen* 50 (2004), 2

[51] e.g. Thompson, Paul B., Uncertainty Arguments in environmental issues, *Environmental Ethics* 8 (1986), 59-75 // Kaplan, Stanley, Garrick, John B., On the quantitative definition of risk, *Risk Analysis* 1(1) (1981), 11-27

[52] Note that here `scenario' is used as it is defined in risk analysis and not as it was defined in section 1.

outcomes. With this enlarged set of outcomes, one can proceed the same way as for decisions under uncertainty.

Settling for option (iii) again leaves us with the question of whether to take a reduction approach and treat the decision as if it would be a decision under risk where we argued for a probabilistic decision model, or whether to settle for maximin. Again the answer to this question depends on the numerical values and the reliability not only of the known outcomes but of the probability estimates as well. Furthermore, `information' on unforeseen consequences which is available in most practical cases seems relevant here. This information concerns for example the novelty of the action or its possible influence on complex systems.[53]

To conclude this section, if an evaluation – that is itself not under the scope of philosophical ethics, but that is initiated by moral arguments – shows that all subjective probability estimates for all known consequences as well as for `the other scenario' are reliable, then we argue for a reduction approach that treats decisions under ignorance and uncertainty in the same way as decisions under risk. For decisions under risk we argued for a probabilistic account that takes into account higher moments and is not restricted to the expectation value. If the subjective probability estimates seem unreliable, maximin is the favorable approach. It shall be stressed that according to the foregoing analysis, (applied) ethical reasoning has to look not only at the strength of the expected harms and benefits as is often suggested in the context of a future ethics facing the problem of `uncertainty'. Ethical reasoning has rather to take into account also the numerical values of their incident rates as well as the ways the occurrence probabilities were generated: via frequency estimates with enough data points, with frequency estimates in oversimplified models, as guesses of some specialist, ... As we have seen in the case of the anthropogenic greenhouse effect, estimation of the long-term consequences of present actions quite often are the result of analysis in many different fields. The necessary estimation of the reliability of the accessible forecasts thus entails interdisciplinary work that sofar is missing in many fields – most strikingly in our example of a possible man-made global warming.

IV. The limits of rule-based approaches

Although it is not the primary task of moral philosophy to reason about the reliability of scientific forecasts, it seems up to ethics to provide the decision maker with a kind of

[53] Hansson, Sven O., Decision Making under Great Uncertainty, *Philosophy of Social Science* 26(3) (1996), 376

`threshold' that indicates when a reduction approach is appropriate. The problems encountered in setting this threshold parallel to some extent the problems encountered when classifying a given decision situation as a decision under risk, uncertainty, or ignorance. Here the second incertitude of demarcation comes into play. The problems related to the second incertitude of demarcation, – the determination of the decision horizon – are analyzed. Then the first kind of incertitude of demarcation, which concerns the unfinished list of decision options, is discussed. The problems we will encounter in both subsections can be interpreted in such a way that a context-independent approach is not capable of treating certain aspects of decisions under `uncertainty' adequately. A possible solution to this problem is suggested in subsection at the end of this section.

1. Setting the decision horizon

The further the expected outcomes of a decision reach in time, the more severe the problems seem to be involving the second kind of incertitude of demarcation. As the example illustrates, there is a plethora of various ways as to how to settle the decision horizon.

Decision theory touches on this problem, although it is not the core of its interest. A formal way of how to deal with it was, for example, proposed by Savage. He begins his analysis from `the grand world', a hypothetical set Z_0 of states of the world that describes the decision situation as accurately as possible. Z_0 is then divided in classes in such a way that states that cannot be distinguished with respect to *some criteria* relevant for the considered decision belong to the same class. The thus obtained partitions A_i form a new set, Savage's `small world'.[54] The relevant question for tackling the second incertitude of demarcation, namely, to state criteria on how to form this partition, is not answered by Savage or in any other decision theoretical approach.[55] Hansson lists some criteria for making such a decision.[56] He illustrates them by the problem of how to combine the different decision horizons of various interest groups in the discussion about nuclear waste disposal. We do not comment on the guide mentioned by Hansson. We only point out general difficulties which arise when one wants to state context-independent criteria to determine the decision horizon. It became clear that settling of the second demarcation problem depends on many context-

[54] Savage 1954, 9, 82ff. See Spohn 1978, 54ff. for a detailed discussion of the `small world'-conception.
[55] Savage, Leonard J., The Foundations of Statistics, 1954, 16 // Spohn, Wolfgang, Grundlagen der Entscheidungstheorie, 1978, 63 // Schmidt, Thomas, Rationale Entscheidungstheorie und reale Personen. Eine kritische Einführung in die formale Theorie individueller Entscheidungen, 1995, 57
[56] Hansson, Sven O., Decision Making under Great Uncertainty, *Philosophy of Social Science* 26(3) (1996), 373-375

dependent aspects, for example: Do some of the actions have similarity with any decision in the past? What is the nature of the system our decision is touching on, does it entail feedback processes? Answering these questions, we have to take into account that on the one hand it speaks in favour of a wide decision horizon that only thereby we can account for the complexity of the actual situation. On the other hand, due to cognitive limitations, wide decision horizons are extremely difficult to handle.

2. Handling an unfinished list of options

In order to account for the first kind of incertitude of demarcation we can distinguish between three different approaches: (i) Postponing the decision and hoping that at some later time we will know more about possible decision options, (ii) solving the problem permanently now although we may have not yet identified most of the possible actions, or (iii) settling for a preliminary solution while at the same time looking for further decision options which may qualify as solutions for longer periods or even as permanent ones. Approaches (i) and (iii) clearly entail demands for more research in the specific field in order to be able to identify yet unknown decision options. Alternative (i) is a distinct option only if doing nothing now is not yet a `decision by default'. As already stated in section II, this seems quite often not to be the case. For example for the anthropogenic greenhouse effect, to wait until the search for further courses of action has been successful – for example, a search for more energy-efficient techniques, new ways of energy conversion, or means to absorb greenhouse gases – might already undermine the possibility to `solve' the problem of a man-made climate-change at some later time. A permanent solution to the climate problem could be to forbid completely man-made emissions of greenhouse gases, while a temporary reduction of emissions and investment, for example, in research for more energy-efficient techniques constitute preliminary solutions. The question for moral philosophy is as to how to set on moral grounds a kind of `threshold' between the three options (i) --(iii). Again the answer hinges on many context-dependent features, for example, on how settling for one specific scenario, restricts the number of possible future decisions. Furthermore it might be of importance for how long and how extensively alternative decision options have already been searched for or if there have been similar decision situations in the past.

3. Judgment as a supplementation of rules

According to the analysis of the forgoing subsections, with respect to the incertitude of demarcation a solution detached from contingent features of the decision situation seems to be

out of reach. We encountered similar difficulties when we were treating decisions under uncertainty and under ignorance: Although we argued for a general guideline – a probabilistic decision model that takes into account higher moments of the probability density, when facing decisions under risk – we could not give a general context-independent rule when to settle for a `reduction approach', that is, when to accept subjective probability estimates and treat decisions under uncertainty or ignorance in complete analogy to decision under risk. The analysis in this article thus raises the conjecture that any general rule is doomed to fail in treating adequately the problem of the incertitude of demarcation. With respect to the colloquial use of the term `uncertainty' M. Luntley notes something similar:

> The ethically competent need general rules, but these are not what primarily lie behind ethical competence in decision making. Wise judgement is not constituted by grasp of general rules, but by the attentional skills for finding salience in the particularities of situations. The important element of decision making [...] is the element that turns on the possession and operation of these attentional skills.[57]

We want to argue that the conceptual skill Luntley mentions should be identified with Aristotle's dianoetic virtue of phronesis[58] as it is used by O. Höffe in the context of an ethics of science and technology.[59] But contrary to Luntley who does not distinguish `uncertainties' which are different with respect to context (see section II), we hold the opinion that for treating the incertitude of consequences adequately, general `rules' of the form given by welfare based ethics seem to be required. A synthetic approach, combining welfare based ethics and a virtue ethics approach as it shall be sketched in the following, might be able to cope with the `uncertainty' of decisions in the full meaning of the word.

Höffe follows the antique understanding of phronesis: Judgement in this context labels a certain ability and willingness to identify and to implement the ways and means of how to realize a moral norm in real life situations.[60] This antique phronesis as a judgment obliged to judge on moral grounds seems to have been diminished with time: In modernity ethics and judgment seem to decouple, judgment becomes equal to a cleverness which is neutral with respect to ethical reasoning. Although this cleverness was already known as panurgia in

[57] Luntley, Michael, Ethics in the Face of Uncertainty: Judgement not Rules, *Business Ethics: A European Review* 12(4) (2003), 326
[58] e.g. NE, VI 8--19
[59] Höffe, Otfried, Moral als Preis der Moderne: ein Versuch über Wissenschaft, Technik und Umwelt, 1993
[60] Aristotle NE, VI 8-19

antiquity, it is only in modern times that it seemed to be looked upon favourably.[61] As we will argue in the following, the problem we face when dealing with decisions under `uncertainty', seem to enforce a reversement of the depotensation of the antique phronesis.

4. Necessity for a Dianoetic Approach

Not only do the many context-dependant features which seem to be relevant for coping with this incertitude of demarcation undermine an overall, context-independent approach in the form of general rules. Rather it seems that the complexity often related to the incertitude of demarcation implies that quite often only people actually involved with the sometimes rather complex prognosis are able to determine the decision horizon and determine how to treat the unfinished list of options in such a way that it does justice to problems in the real world. But only by first determining the decision horizon, a specific decision situation can indeed be identified as morally relevant. If indeed only specialists who are not experts on moral philsophy are able to do this, the phronesis is of essential importance: For determining the decision horizon, for example, specialist knowledge is necessary, but not sufficient; the people in possession of the relevant knowledge must also have the ability and willingness to determine, for example, the decision horizon on moral grounds.

Thus a first task of the phronesis is to distinguish certain decision situations as ethically relevant. As well as determining the decision horizon, this first task of the phronesis is to identify a way of how to deal with an unfinished list of options: This determines whether the ethical assessement has to be done right now or if it can wait for a better prognosis. A second task of the phronesis is the application of (general) rules. Thus the phronesis arbitrates between general normative rules – as they were, for example, derived in section III – and a specific decision context. With respect to decisions under uncertainty or ignorance, the phronesis is thus in charge of setting in a specific decision context the threshold when to accept a reduction approach and when to settle for maximin. This second duty of the phronesis parallels, to some extend, the duty that according to Kant has to be done by judgement, Kant's `praktische Urteilskraft'.[62]

It seems thus that a rehabilitation of an antique dianoetic virtue is capable of solving problems that are to some extent genuinly modern. But unlike in in antiquity, where it could be expected that everyone with some experience and the relevant knowledge combined with a

[61] Aristotle EN, VI 13
[62] *Vorrede* zur GMS, BA IX

certain willingness was able to determine on his own how to act morally correctly in a given situation, this is not the case when we are confronted with `uncertainties' related to decisions that touch on the remote future: First, the complexity makes it indispensable for moral philosophy to provide the moral agent with some general guidelines. Second, the complexity of many prognoses makes it not only impossible for the layman to judge by its own; rather the nature of the prognoses makes an interdisciplinary assessment inevitable. The example of the man-made greenhouse effect shows this paradigmaticly (see fig. 2).

V. Conclusion

We addressed the question of how ethical reasoning can cope with the 'uncertainty' related to decisions that touch on future generations by distinguishing two distinct sets of problems:

(i) Has this 'uncertainty' implication for our moral obligations towards futurity?
Are due to 'uncertainty' some ethical concepts per se inapplicable to a future ethics?

(ii) Assuming a moral obligation towards futurity, how can moral norms incorporate the 'uncertainty' that cannot be eliminated from real life decisions?

Regarding (i) above, for problems that are presently relevant in moral practice, the moral obligation towards futurity is not challenged by the 'uncertainty' of the existence and of the ways of living of future people. Only special forms of welfare-based approaches, that take into account in ethical reasoning all preferences of the people a specific decision touches on, are doomed to fail. The latter is of central importance as welfare based approaches seem to be most suitable for handling the problems of moral dilemmas which are central in any future ethics.

Regarding (ii), we distinguished three kinds of 'uncertainties', namely incertitude of reliability, of consequences, and of demarcation . The preceding analysis seems to imply that, although the different incertitudes are interrelated, they have to be incorporated in ethical reasoning in quite different ways. Coping with the incertitude of reliability is not primary the task of moral philosophy. Nonetheless, the ontological difference between subjective probabilities and frequencies was shown to be relvant to ethical reasoning. With respect to the incertitude of consequences a welfare-based approach incorporating elements of decision theory that are not restricted to the expected utility seemed well suited. Concerning the incertitude of demarcation a general rule -based approach seemed to fail. This lead us to the

conclusion that decisions under `uncertainty' are too complex as that the question of morally correct actions can be reduced to one of the aspects that are in the forefront of various ethical concepts. Rather a synthetic approach that combines aspects of welfare-based approaches with a dianoetic virtue can account for the encountered complexity.

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