2. Stating the Problem: Radical Uncertainty

Abstract
The aim here is to state the problem of this research. Based on a review of economic research on climate change, it is argued that radical uncertainty, the uncertainty inherent in the human condition, is not adequately addressed by the critical assumptions underlying conventional economic modelling, in particular the social cost-benefit analysis (SCBA). This is supported by an illustration of a controversy between leading economists William Nordhaus and Nicolas Stern. Following Dan Rodrik's approach to economics, the critical assumptions underlying SCBA are questioned, resulting in the necessity for alternative assumptions to address more properly radical uncertainty. After an overview of economic literature on radical uncertainty, the study chooses a theological track to investigate alternative critical assumptions. There follows a review of eco-theology, which leads to the work of Jonathan Sacks.

Keywords: Dan Rodrik, William Nordhaus, Nicolas Stern, social cost-benefit analysis, decision-making under radical uncertainty, eco-theology, Jonathan Sacks

2.1 Introduction

In this chapter I state the problem of this study. I start by defining economics. Then, I give a review of the economic research on climate change, which leads to discussion of the SCBA as an important tool to support decision-making in the context of climate change. In section 3 the role of the Ramsey rule within SCBA is discussed. Section 4 presents the Stern/Nordhaus-controversy in order to illustrate difficulties with the Ramsey rule. In section 5 it is argued that these difficulties have to do with the uncertainty involved. Section 6 presents several faces of uncertainty in climate change and introduces the

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concept of radical uncertainty. Section 7 discusses radical uncertainty in economic research, which invites a section on theology, climate change and radical uncertainty (section 8). Section 9 concludes this chapter.

2.2 Economics

Let me introduce my formulation of the problem statement by explaining what I mean by economics. In this study I employ an approach to economics as expressed in Dan Rodrik's *Economics Rules* (2015). In his view, economics is not primarily a social science devoted to understanding how the economy works, but a way of doing social science. Rodrik describes economics as a collection of models to study social life. (2015, p. 7) By doing so, he criticizes the tendency among economists to consider economics the province of universal laws like natural sciences. Rodrik states that economists, generally speaking, "… are prone to mistake a model for *the* model, relevant and applicable under all conditions" (Rodrik, 2015, p. 6). In his view, "we cannot look to economics for universal explanations or prescriptions that apply regardless of context. The possibilities of social life are too diverse to be squeezed into unique frameworks" (Rodrik, 2015, p. 8). Rodrik views an economic model as a partial map that illuminates a fragment of social life in order to enhance our understanding of how the world works and how it can be improved (2015, p. 83). For him:

> What makes a model useful is that it captures an aspect of reality. What makes it indispensable, when used well, is that it captures *the most relevant aspect of reality in a given context*. Different contexts -different markets, social settings, countries, time periods, and so on – require different models. (Rodrik, 2015, p. 11)

In this quotation, Rodrik states that an economic model is useful when it directs attention to only the aspects of reality that really matter. For Rodrik, the strength of an economic model is that it simplifies the world by highlighting only the most relevant aspect in a certain context. "We can understand the world only by simplifying it" (Rodrik, 2015, p. 44). The most relevant aspect of context has to be sufficiently represented by what Rodrik calls the 'critical assumptions' of a model. "We can say an assumption is critical if its modification in an arguably more realistic direction would produce a substantive difference in the conclusion produced by the model" (Rodrik, 2015, p. 27). The key skill of an economist, for Rodrik, is to wisely

pick from the menu of available alternative models in each setting. The applicability of a model in a setting depends then on how closely its critical assumptions approximate reality. Rodrik argues that it is not only perfectly legitimate, but also necessary, to question a model's efficacy when its critical assumptions do not sufficiently approximate the given setting. In such a case, the appropriate response is "… to construct alternative models with more fitting assumptions—not to abandon models per se" (Rodrik, 2015, p. 29). Economics, as defined here, is not limited to any single economic school of thought that makes a priori assertions of a general kind about the world, for example only neoclassical or behavioural thinking. Economics is defined as drawing on any or all schools of thought—neoclassical, social, neo-Keynesian, Austrian, behavioural, institutional, ecological, etc.—as long as they offer relevant insight in the context of a particular problem.

For Rodrik the focus of economics is on problem solving. "Economics provides many of the stepping-stones and analytic tools to address the big public issues of our time" (Rodrik, 2015, p. 211). In section 1.4 we have seen that climate change is one of the big contemporary public issues. Economics has an extensive toolbox of models that have been applied to climate change. In the following I give a review of the economic research on climate change in order to state the problem of this study.

2.3 Economics on climate change

Within economics the global climate can be described as a public good. The climate meets the two characteristics of a public good. First, those who fail to pay for it cannot be excluded from using it (non-excludable). Second, one's enjoyment of the climate does not diminish the capacity of others to enjoy it (non-rivalrous). (Perman, Ma, Common, Maddison, & Mcgilvray, 2011, pp. 113-115)

Another key characteristic of the public good of the climate is that of an externality. An externality arises when in an exchange the action of one agent, producer or consumer, affects others that are absent or incompletely represented in the exchange. Therefore, they do not reward the actor for the benefits or penalize him or her for the costs. The market then does not provide an optimal level of resource allocation, which is called a market failure. Externalities fall into two categories. The first category is called positive externalities. These externalities are those where production or consumption decisions of one agent have a positive impact on others in

an unintended way, and when no compensation is made. An example of a positive externality is the outcome of Research & Development (R&D). The second category is called negative externalities. This means that producers or consumers do not pay compensation to those who bear the negative effect of action. (Perman et al., 2011, pp. 121-1214)

Economic activities based on the burning of fossil (or carbon-based) fuels involve the emission of CO_2.[1] When CO_2 accumulates in the atmosphere, the temperature increases, and the climatic changes that result, such as changes in temperature extremes, precipitation patterns, rise of sea level, storm location and frequency, snow packs and water availability, impose costs (and some benefits) on society. However, the full costs of CO_2 emissions, in terms of climatic changes, are not immediately borne by the emitter. As a consequence, the emitter faces little or no (economic) incentive to reduce emissions. Similarly, emitters do not have to compensate those who are affected by climatic changes, now or in the future. In this sense, one can describe anthropogenic, i.e. human induced, climate change as (the result of) a negative externality.

Within economics, whenever externality or market failure occurs, there is a potential role for a central decision maker or social planner to internalize the externality. The model of the social cost-benefit analysis is an important economic tool to support the decision maker, often the government, in answering the question of how to internalize the externality. In choosing among alternative trajectories, SCBA attempts to balance objectively the costs of reducing CO_2 emissions with the perils of inaction to a socially optimal level.

The SCBA is built upon the critical assumptions of neoclassical economics. Samuel Bowles calls this the conventional framework within economics (Bowles, 2004, pp. 99-101). The reason for this is that the neoclassical school of thought dominates economics. I use the terms 'neoclassical' or 'conventional' economics interchangeably. In the following I explicate the assumptions underlying the conventional framework. The first assumption of the conventional framework is that knowledge is objective, in other words knowledge is independent of an observer's viewpoint or bias (Horowitz, 2005, p. 1657). The decision maker is able to maximize utility or satisfaction of needs by choosing objectively the optimal alternative, which is preferable to every alternative available to them. The second assumption is that the

1 In this study CO_2 is used as shorthand for greenhouse gases (GHGs) that include carbon dioxide (CO_2), nitrous oxide (N_2O), and halocarbons (a group of gases including chlorofluorocarbon (CFC).

unit of analysis is one dynasty of households. This dynasty includes all interests involved, not only those of the present generation, but also those of the next generation. In order to keep the analysis simple the interests of the members of one dynasty are commonly assumed in terms of a 'representative individual'. This is an attempt to 'microfound' macroeconomics, which means that "… all general outcomes need to be explained in terms of the rational choices of isolated individuals" (Skidelsky, 2020, p. xiv). In other words, this dynasty fiction is not a standard element of conventional economics, but rather a working hypothesis to allow working on long-term intertemporal utility optimization. The third assumption is about fixed preferences. This means that what people want among the alternatives in the world is exogenously given, and therefore fixed within the model.

Within SCBA, the Ramsey rule is an important organizing concept for thinking about intertemporal decisions. The reason for this is that in choosing among alternative trajectories for CO_2 reduction, future costs need to be translated into present values. In order to increase consumption in the future, economies invest today in capital, education and technologies. By doing so, they abstain from today's consumption. The Ramsey rule is a mathematical approach to intertemporal decision-making. In the following, I try to explain this rather mathematical rule.

In choosing among alternative trajectories of CO_2 reduction, a key economic variable in the Ramsey rule is the real return on capital, r. The real return on capital measures the net, i.e. subtracting all expenses, yield on investments. Within the context of climate change, the Ramsey rule models the real return on capital, real interest rate or the opportunity costs of capital, r, as the sum of three components:

$$r = \rho + \alpha g$$

where ρ is the time discount rate. This parameter expresses the importance of the welfare (or more precisely, consumption) of future generations relative to the present. When the time discount rate is zero it means that future generations are treated like present generations. A positive discount rate means that the weight placed on the welfare of future generations is reduced compared with nearer generations. The real return on capital depends also on the elasticity of the marginal utility of consumption, α. This consumption elasticity can be seen as a societal preference for consumption smoothing, inequality aversion or risk aversion. The last parameter of the equation is the growth of consumption per generation, g. This parameter includes not

only economic growth, but more implicitly also, for example, expectations about the development of technology. (Gollier, 2018, p. 85)

In SCBA, including the Ramsey rule, key questions are: How much should countries reduce CO_2 emissions? When should they reduce emissions? How should the reductions be distributed across industries and countries? What may be the costs of a reduction of CO_2?

Espagne, Nadaud, Fabert, Pottier and Dumas (2012) rightly argue that SCBA becomes controversial in answering these questions. Controversies about the Ramsey rule have been central to responses to climate change for many years (Gollier, 2018, p. 161). One controversy stands out, the Stern/Nordhaus-controversy. In the next section this controversy is discussed in detail in order to trace the hidden dimension of uncertainty in the economics of climate change.

2.4 Stern/Nordhaus-controversy

Two of the most prominent and respected economic studies in the discourses around climate change are those of William Nordhaus and Nicolas Stern. Since the late 1970s Nordhaus has been developing his DICE model. In 2018 Nordhaus received the Nobel Prize in Economic Sciences for his pioneering work on the economics of climate change. Here we focus on his DICE-2007 model. (Nordhaus, 2008) This is a global model that aggregates different countries into a single level of capital, technology and emission. The world is assumed to have a well-defined set of preferences, which ranks different paths of consumption. In his SCBA Nordhaus tries to integrate the main components of society, economy, biosphere and atmosphere, in order to determine the social cost of carbon. Such an analysis is called an Integrated Assessment Model. One assumption of the model is that economic and climate policies should be designed to optimize consumption over time, up to about 200 years ahead. Different strategies for climate change will yield different patterns of consumption. Consumption is viewed broadly and includes besides food and shelter also nonmarket environmental amenities and services.

In 2005, the Stern Review was commissioned by the government of the United Kingdom, and named after the head of the team, Nicholas Stern. Stern was asked to lead a major review on the economics of climate change in order to understand more comprehensively the challenges of climate change and how to respond to them. The Stern Review, which appeared in 2006, uses the PAGE model, which has the same framework of SCBA

as Nordhaus' DICE model. However, within the model they proceed from different parameters. The Stern Review uses a discount rate of 0.1 percent per year. Stern argues that the welfare of future generations should be treated on a par with our own (Stern, 2006, p. 35). Nordhaus argues for a discount rate of 1.5 per year (Nordhaus, 2008, p. 178). The Stern Review assumes a consumption elasticity of 1, Nordhaus one of 2. The Stern Review adopts a consumption growth rate of 1.3%. Nordhaus argues for a growth rate of 2%. We have seen that the real return on capital is given by $r = \rho + \alpha g$. As a consequence, the Stern Review results in a real return on capital of 1.4 percent per year. Nordhaus presents a real return of 5.5 percent per year. The real return and its components as presented in the Stern Review and Nordhaus are summarized in table 2.1.

Table 2.1 Real return on capital and its components for Stern (2006) and Nordhaus (2008)

	Stern Review	Nordhaus
ρ	0.1	1.5
α	1	2
g	1.3	2
R	1.4	5.5

Using a real return of 1.4 percent, Stern arrives at a present value of future climate damages of around $85 per ton of emissions. This means that an action to reduce CO_2 should be undertaken if it costs less than $85 per ton of emissions. Under these conditions, most environmental projects (such as carbon sequestration, wind power, photovoltaics, and biofuels) are socially desirable. However, Nordhaus, using a real return of 5.5 percent, arrives at a much lower present value of future damages of around $8. (Gollier, 2018, p. 73) As a result, the principal conclusion of the Stern Review is that strong and early actions should be taken to reduce CO_2. One of the main results of Nordhaus' DICE model is that the best response to climate change is not to invest heavily using current technologies, but rather to invest in R&D of more efficient technologies before attempting to reduce CO_2. The different outcomes of the models of Nordhaus and Stern lead to different, even conflicting, advice to a decision maker about how to respond to climate change. Espagne et al. (2012) even argue that the Stern/Nordhaus-controversy has polarized the question about how to respond to climate change.

The Stern/Nordhaus controversy has mainly focused on the role played by the choice of the discount factor. Nordhaus points to the fact that, because

of the assumption about discounting, the results of the Stern Review differ dramatically from those of earlier economic models that use the same basic data and analytical structure (Nordhaus, 2008, p. 169). He argues that a time discount rate of 0.1 percent per year represents a shift from mainstream economic theory. But, as indicated in table 2.1, there is also disagreement about the consumption elasticity and the growth rate per capita consumption. In the latter, in both cases the question can be raised as to how such growth rates of 1.3%. (Stern) and 2% (Nordhaus) relate to the expected environmental dangers. Espagne et al. (2012) also highlight the importance of disagreement between Nordhaus and Stern on two other parameters: technical progress on abatement costs and the climate sensitivity.

2.5 Uncertainty

The reason why Stern and Nordhaus disagree so strongly, while using the same conventional economic model, has to do with the fact that the used model does not represent uncertainty. The aim of a SCBA is to support a decision maker objectively in the question of how to internalize an externality. The question is whether it is possible to compensate for this lack of objective probabilities. When there is a lack of objective knowledge, conventional economic theory proceeds by assigning 'subjective' probabilities to each of the possible outcomes that it has identified. There is no single tool to deal with 'subjective' probabilities. Economists use a variety of techniques, for example decision theory (game theory), Bayesian judgements (an estimation of the probability of an event occurring by an individual or a group of individuals), betting markets (predicting markets) and expert elicitation (judgement of more experts together) (Hulme, 2009, p. 85; Nordhaus, 2008, p. 125).[2] Generally speaking, especially in a 'small world', when there is a lack of objective knowledge, "… economists have been able to provide decent enough estimates to facilitate decision making" (Van Kooten, 2013, p. 217). However, in the large world, controversies related to the discount rate, in particular the one between Stern and Nordhaus, show that these techniques inevitably contain subjective elements, which lead to different, even contrasting

2 Another way to deal with uncertainty in SCBA is to incorporate a risk premium into the discount rate. This risk premium is supposed to reflect the uncertainty involved. See for example Lemoine (2020).

outcomes. Subjective knowledge is the knowledge an individual has about a situation or phenomenon based on personal opinions, biases, and preferences (Bunnin & Yu, 2004, p. 663).

Van Kooten argues that uncertainty within the context of climate change poses a particular challenge to the economics on externalities (2013, p. 217). In climate change there is not just one uncertainty, but climate change is surrounded by many uncertainties (Heal and Kristöm, 2002; Quiggin, 2008; Van Kooten, 2013, p. 9). There is for example uncertainty about climate sensitivity. This is about the relationship between the human-caused emissions and the temperature changes that will result from these emissions. There is also uncertainty about emission scenarios; this is the future growth or reduction of CO_2 emissions. Uncertainty can also refer to the impact of feedbacks. The effects of global warming have created all kinds of feedbacks in the atmosphere, ocean and land, for example acidification of the oceans, rise of the sea level, increased droughts and floods, more intense storms and more extreme heat episodes. Finally, even if we were able to know accurately and in detail how the climate is going to change, we would still not be able to fully describe the effect on human behaviour.

Due to the many uncertainties involved, economists and their studies often disagree strongly with one another about estimations and value judgements like economic growth and the discount rate, as illustrated by the Stern/Nordhaus-controversy. When uncertainty is at centre stage it appears impossible to make decent enough estimations to guide collective decision-making. This leads to questions like the following: How to proceed if an economic model, that should guide collective decision-making, leads to contrasting outcomes? How should uncertainty affect a collective response to climate change?

Haurie, Tavoni and Van der Zwaan argue that much progress has been made in the economics on climate change over the past decade:

> The formulation of climate policy is increasingly becoming reliant on the adequacy of economic analysis, yet many of its aspects are left poorly understood… Among the subjects that deserve further in-depth investigation, the issue of uncertainty emerges as, perhaps the most prominent. (2012, p. 1)

The focus of this study is on uncertainty in the context of climate change. The next step is to define which uncertainty of the many possibilities we wish to examine.

2.6 Radical uncertainty

Within the context of climate change there is not just one uncertainty. Climate change is surrounded by many uncertainties. There is, for example, uncertainty about climate sensitivity. This turn of phrase deals with the relationship between the human-caused emissions and the temperature changes that will result from these emissions. There is also uncertainty about emission scenarios; here lies the pressing concern regarding the future growth, or reduction, of CO_2 emissions. Finally, even if we were able to know accurately, and in detail, how the climate is going to change, we would still not understand fully the implications for social and economic activity. In addition, there is also uncertainty about how technology will develop, for example in areas of green energy and climate engineering.

Uncertainty in the context of climate change is attributed to two main sources by Heal and Millner (2013). The first source is scientific uncertainty, an incomplete understanding of the climate system and related parameters. One can refer here for example to climate sensitivity (relation between atmospheric CO_2 concentration and global average temperature). The second source of uncertainty is socio-economic uncertainty, an incomplete understanding of the impacts of climate change on people and societies, how people and societies will respond, and related parameters. One can refer here for example to parameters related to future policies such as economic growth.

I am adding a third source of uncertainty, which might best be termed 'radical uncertainty'. It is a source of uncertainty inherent in what Hannah Arendt has called 'the human condition of existence'. Hannah Arendt (1906–1975) is considered as one of the most important and original political philosophers of the twentieth century. Although Arendt did not subscribe to a specific school of thought, she did describe herself as a sort of phenomenologist. By this she means that her point of departure is lived experience (Hayden, 2014, p. 10). To put it in her own words from the prologue of *The Human Condition*: "What I propose in the following is a reconsideration of the human condition from the vantage point of our newest experiences and our most recent fears" (Arendt, 1958, p. 5). Arendt insists on taking seriously the basic conditions of human existence, namely life itself, birth and mortality, natality (the capacity to bring something new into the world), worldliness, plurality and the earth (Arendt, 1958, p. 11). Arendt's concept includes the recognition that humans have the freedom for speech and action, which means that there is always the possibility that people can do or say new, unexpected and unprecedented things. As a consequence, the future cannot

be predicted in advance. By making the human condition her starting point, Arendt argues against the mainstream Western philosophical tradition, in particular Platonic and Christian worldviews with their emphasis on non-earthly matters and an abstract conception of 'man' (Hayden, 2014, p. 30).

Arendt's concept of the human condition is highly relevant in the context of this study. It shows that we live in a world of radical uncertainty in which our understanding of the present is imperfect, while our understanding of the future is even more limited. As a consequence, this source of uncertainty permeates the two other sources of uncertainty: scientific uncertainty and socio-economic uncertainty. Therefore, human knowledge is limited, and the future cannot be predicted.

Van Kooten points explicitly to the fact that radical uncertainty cannot be ignored in the context of climate change, especially when it comes to long-term decision making. He argues that one hundred year ago automobiles, electricity, airplanes and computers were largely unknown, but that today we cannot envision doing without them. He then wonders: "How can we predict potential damages (or benefits) from climate change in 2050 or 2100, much less 2200, without knowing the technical, social and economic changes that will occur on a global scale during that period?" (Van Kooten, 2013, p. 218). In this research I place radical uncertainty within the context of climate change at the core of the investigation.

2.7 Economics on radical uncertainty

In this research I employ an approach to economics as expressed in Dan Rodrik's *Economics Rules* (section 2.2). Following Rodrik's approach, an economic model is a way to organize our thinking. An economic model is useful when its assumptions capture only the most relevant aspects of reality. In section 2.3 we have seen that the SCBA, part of conventional economics, is an important economic model to support the decision maker in the question of how to respond to climate change. The underlying assumptions of the SCBA are: (1) objective knowledge, (2) the unit of analysis is one dynasty of households, represented in terms of a 'representative individual', and (3) fixed preferences. However, we have seen above that critical assumptions underlying SCBA do not sufficiently address radical uncertainty in the context of climate change, especially the first and third assumption.

The first assumption refers to objective knowledge. However, when it comes to radical uncertainty in the context of climate change, one cannot determine objectively the optimal level of decision making. Economists use a

variety of techniques to substitute for a lack of objective knowledge. However when it comes to climate change, uncertainty is at centre stage. As a result, the outcomes of different SCBA, developed to guide objective collective decision-making, can differ widely due to the subjective elements in the estimated parameters, as illustrated by the Stern/Nordhaus-controversy.

The second assumption is a unit of analysis that includes the interests of the members of one dynasty of households. At first sight, this assumption does not run into serious limitations when it comes to radical uncertainty in the context of climate change. However, from chapter 4 onwards we will see that the commonly assumed simplification of representing the interests of one dynasty in terms of a 'representative individual' does not sufficiently address radical uncertainty.

The third assumption refers to the fact that what people prefer is given. However, due to radical uncertainty, it is also impossible to know in advance, especially over long-time horizons, what people will prefer. There is imperfect knowledge about the scope and impact of climate change, but also about future economic growth, including the development of technology.

In addition, although implementation is not part of the SCBA, when externalities arise, a social planner, often the government, intervenes by law, taxes or/and subsidies to internalize the externality. In the context of climate change as a global issue, such a planner, a global authority, does not exist. Even if it were possible to develop objectively an optimal level, there is no global authority that can intervene. In other words, in the context of climate change there is also a governance problem.

How then should we formulate a response to climate change? Employing Rodrik's approach to economics requires not only that we question a model's efficacy when its critical assumptions do not sufficiently cover the given context, here radical uncertainty in the context of climate change. It also challenges us to contribute to more fitting critical assumptions.

In the research tradition of economics in the 20th century[3], there are several prominent economists that acknowledge uncertainty as a fundamental source in economic theory: (1) Frank Knight (1885-1972), (2) John Maynard Keynes (1883-1946) and (3) Friedrich von Hayek (1899-1992).

(1) Knight started the debate in the 1920's by distinguishing, in his classic book *Risk, Uncertainty and Profits* (1921), the difference between risk and uncertainty as two different types of imperfect knowledge about the

3 For an account of the role of uncertainty in early modern economics, see Köhn (2017, Chapter 2).

future. For Knight, risk is a known change, quantitatively measurable, while uncertainty is unmeasurable. Köhn argues that the key distinction between the two types is not about the availability of probabilities but about the limits of human knowledge. Some knowledge imperfections can be overcome, as in a classic risk situation like gambling. Other situations of imperfect knowledge cannot be overcome due to human limitations and people's freedom of action and speech. This has consequences for decision-making under conditions of uncertainty. It is meaningless to develop subjective probability calculus in the face of uncertainty. Knight argues for intelligible, wise, creative and entrepreneurial decisions to guide actions in situations of uncertainty. (Köhn, 2017, p. 98) To complete Knight's argument, uncertainty leads to imperfection competition–as opposed to perfect knowledge and perfect competition–which is the cause and ground of profit. Profit is the reward the entrepreneur gains for bearing uncertainty. (Köhn, 2017, p. 100) By referring to the limits of human knowledge, Knight classifies the distinction between risk and uncertainty in terms of epistemology, i.e. it is about limits and reliability of claims to knowledge. What is more, to Knight this distinction is not only a result of cognitive limitations of human actors (epistemological), but lies also in the nature of the real world (ontological).

(2) Keynes states that in a radically uncertain world investors may become pessimistic about the future and reduce their investments. For Keynes, when investments fall, overall spending falls. Government intervention is required to achieve full employment and price stability. Keynes thought that investment will be high enough for full employment only when the animal spirits of the potential investors are stimulated by new technologies, financial euphoria and other unusual events. The term 'animal spirits' is used by Keynes in chapter 12 *The State of Long-Term Expectation* concerning entrepreneurship and long-term investment. Keynes does not define 'animal spirits' precisely, but he associates it with spontaneous optimism, confidence, hope, nerves, hysteria, whim, sentiment or chance. 'Animal spirits' is not used here as a technical term, but much more literally. It is an umbrella term for ingredients for investments on the long term which are not 'reasonable calculations'.

(3) Hayek rejects government intervention. First, because the central planner, the government, does not have all the relevant information. Second, the centrally planned economic model provides too little incentive for effort and creativity. (Hayek, 1945; 1989) For Hayek, it is only through the spontaneous order of the competitive market that the diverse and ever-changing plans of numerous economic actors, responding to unpredictable and complex

shifts of the world, can be reconciled with one another. In other words, for Hayek, the spontaneous order of the free market is the best economic system to deal with radical uncertainty.

In the following I will use the term 'Knightian uncertainty' as a shorthand to bundle uncertainty as a fundamental type of uncertainty in economics, expressed by classical economists like Knight, Keynes and Hayek. I will use 'Ramseyan uncertainty' to refer to uncertainty defined as a risk by attaching subjective probabilities to it, as done in conventional economics.

To sum up, within economics, generally speaking, we can distinguish two types of uncertainty. On the one hand there is the acknowledgement of uncertainty as a fundamental source proposed, although with different accents, by Knight, Keynes and Hayek. On the other hand there is a tradition based on Ramsey which assumes that the knowledge issue related to uncertainty can be overcome on the basis of subjective probabilities, so that decision-making under conditions of uncertainty can be reduced to decision-making under conditions of risk.

In the course of the 20th century the work of Knight, Keynes and Hayek, with their fundamental distinction between risk and uncertainty, was largely side-tracked by conventional economics (Köhn, 2017, p. 4). Ramsey won, and Knight, Keynes and Hayek lost the debate over the interpretation of uncertainty.

The financial crisis of 2007-09 drew attention back to this old debate about the interpretation of uncertainty. Since then, several economists have been rediscovering the theme of radical uncertainty. A prominent voice is Mervyn King, Governor of the Bank of England during the crisis and currently professor of Economics and Law (New York University) and School Professor of Economics (London School of Economics). In his book *The End of Alchemy: Money, Banking and the Future of the Global Economy* (2017), King argues that the financial crisis of 2007-09 was not just a failure of individuals or institutions, but primarily a failure of the ideas that underpin economic policymaking. "There was a general misunderstanding of how the world economy worked" (King, 2017, p. 3). Therefore, King states: "Unless we go back to the underlying causes we will never understand what happened and will be unable to prevent a repetition and help our economies truly recover" (King, 2017, p. 2). In King's view, the failure to incorporate radical uncertainty, in the sense of Knightian uncertainty, into economic theories was one of the factors responsible for the misjudgements that led to the crisis. King

argues that it is not always possible to identify all possible future events, attach probabilities to them, estimate their potential impacts on wellbeing or utility and seek to optimise that utility. He considers radical uncertainty as part of 'the human condition', to use Arendt's phrase.

In recent years other economists have also highlighted uncertainty besides risk. To describe this uncertainty, they use terms like 'deep uncertainty', 'ambiguity', 'fundamental uncertainty' and 'uncertainty in a wide sense' (Wakker, 2011; De Grauwe, 2012, p. 27; Roos, 2015; Trautmann and van de Kuilen, 2015; Li, Müller, Wakker and Wang, 2017; Gollier, 2018, pp. 88-89). According to Koppl and Luther, economists rediscover the theme of radical uncertainty either from a more or less Keynesian or Hayekian perspective, respectively government or market. These perspectives are then regarded as two diametrically opposed forms of governance. It has to be government or market, one or the other. (Koppl and Luther, 2012, p. 224) In this study I go beyond an 'either-or' perspective. I will come back to this in section 6.5.1.

When it comes to climate change in particular, the last decade also shows the emergence of economic literature that seeks to incorporate ambiguity or radical uncertainty. One can mention here non-probabilistic approaches, like the Maxmin approach of picking the strategy whose worst possible outcome (min) is least bad (max). There are also probabilistic approaches like the Maximum Expected Utility, which is a probabilistic equivalent of the Maxmin. (Millner, Dietz and Heal, 2010; Lemoine & Traeger, 2012; Heal & Millner, 2013, p. 14)

In this research I follow a different track to cover radical uncertainty in the context of climate change. I focus on a conversation between economics and theology in order to investigate a response to radical uncertainty in the context of climate change.

2.8 Theology on radical uncertainty in climate change

Climate change is not only a challenge for economics, but also for (Christian) theology. Eco-theology is a new branch of theology that has emerged as theologians have wrestled with challenges like (1) the failure of traditional theologies to respond to the problems of the eco-system, and (2) the criticism of traditional theologies, which are considered anthropocentric. Today there are centres, handbooks, websites and many books and articles on religion and ecology. When it comes to the North Atlantic context, in which I live, one can refer, for example, to the *T&T Clark Handbook of Christian Theology and Climate Change* (2020), the Forum on Religion and Ecology

and the Amsterdam Centre for Religion and Sustainable Development (Vrije Universiteit).[4]

Several categorisations within eco-theology can be made. In the following I give two examples.

(1) Kim identifies four different approaches of eco-theology: social ecology, creation theology, eco-feminism and eco-spirituality (Kim, 2011, p. 61). *Social ecology* follows a liberation theology methodology and seeks to liberate nature from the bondage of socio-political structures. *Creation theology* views the original creation as the perfect model for God's relationship with humanity and the natural world. *Eco-feminism* identifies women and nature as victims of the dominating, male structures resulting in oppression and exploitation. *Eco-spirituality* starts with the interconnectedness of human beings and nature, and includes resources from primal (and other) religions. Primal religions are regarded as yielding deep eco-theological insights.

(2) Deane-Drummond reviews something of the diversity of eco-theological thought by distinguishing eco-theology from different global contexts: North, South, East and West. *Eco-theology from the North*, focuses on writers in the Northern hemisphere like Aldo Leopold, Matthew Fox, Teilhard de Chardin and Thomas Berry. *Eco-theology from the South* refers to various forms of liberation theology, including Leonardo Boff and Sean McDonagh. *Eco-theology from the East* focuses on theologians from the Eastern Orthodox tradition, for example John Zizioulas and Sergii Bulgakov. In *Eco-theology from the West,* Deane Drummond highlights writers with a concern for socio-political issues, like Michael Northcott and Murray Bookchin.

Eco-theology, as a new development within theology, broadens the scope of theology beyond human society to include nature. However, eco-theology has not yet dealt with the specific problem of radical uncertainty within the context of climate change, especially in interaction with economics. The above mentioned *T&T Clark Handbook of Christian Theology and Climate Change*, includes a critique of an article by Eaton on uncertainty in climate change from the perspective of eco-theology, maintaining that it pays too much attention to uncertainty in climate science itself or its computer models (scientific uncertainty) and overlooks uncertainty regarding to human decision-making by individuals, governments and political parties and leaders (socio-economic uncertainty). According to Hayhoe and Hayhoe

4 Forum on Religion and Ecology: https://fore.yale.edu/; Amsterdam Centre for Religion and Sustainable Development: https://vu.nl/en/about-vu/research-institutes/amsterdam-centre-for-religion-and-sustainable-development (accessed 6 December 2022).

the answer to the question of whether the goals of the Paris Agreement will be achieved is not a matter of scientific uncertainty, but will be determined by politics and economics and ideologies that drive our nations. (Hayhoe & Hayhoe, 2020, p. 30). Above I have argued for adding radical uncertainty, derived from Arendt, as a third source of uncertainty. Radical uncertainty permeates both scientific uncertainty and socio-economic uncertainty.

Theology on climate change has not yet dealt with the specific problem of radical uncertainty within the context of climate change. Jonathan Sacks has extensively written on radical uncertainty. Therefore, I propose to use his work to study radical uncertainty in the context of climate change. I will come back to this in chapter 4. First I will discuss a possible conversation between theology and economics.

2.9 Conclusion

In this chapter I have stated the problem of this research, namely that radical uncertainty in the context of climate change is insufficiently covered by the critical assumptions of conventional economics. In economics on climate change the SCBA, an attempt to balance objectively the costs of reducing CO_2 emissions with the perils of inaction to a socially optimal level, is an important model to support a central decision maker. In the chapter it was shown that in the Ramsey rule, an organizing concept for thinking about intertemporal decisions, there is no space for uncertainty. This leads to a polarization in the debate about how to respond to climate change, as illustrated by the Stern/Nordhaus-controversy. It is argued that the critical assumptions of conventional economics run into serious limitations when uncertainty is involved. This study puts radical uncertainty center stage. As used by Hannah Arendt, radical uncertainty refers to a source of uncertainty that is inherent in the human condition. Radical uncertainty implies that human knowledge is limited, and the future cannot be predicted. It is argued in the chapter that this source of uncertainty permeates two other sources of uncertainty in climate change, namely scientific uncertainty and socio-economic uncertainty. Since the financial crisis of 2007-09 economists are rediscovering the theme of radical uncertainty. In this study I follow a different track and focus on an interaction between economics and theology in order to address radical uncertainty in the context of climate change. Eco-theology has not yet addressed radical uncertainty. The chapter proposes using the work of Jonathan Sacks to address radical uncertainty, but first I will explore the possibility of an interaction between theology and economics.

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