Ignorance

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Abstract

The phenomenon of ignorance was an issue in Greek philosophy as early as Plato's first dialogues (e.g. Meno). The importance of the consciousness of ignorance is illustrated by the famous Oracle of Delphi: It acknowledged Socrates as the wisest of all human beings because he said, 'I know that I know nothing'.

Mainstream Economics is particularly strong in dealing with risk and, to some extent, uncertainty. In contrast, Ecological Economics focuses on the boundary between what we know, what we know that we do not know, and where we are even unaware of our lack of knowledge. To this end, we outline different forms of ignorance, such as personal and social, open and closed, reducible and irreducible ignorance. This concept enables us to improve our understanding of natural processes and our political decision-making.

The example of joint production shows how manufacturing one good results in at least one waste product. Various joint products, however, can go unrecognized for a long time, with detrimental effects. Responsible action therefore demands that we deal explicitly with ignorance.

Related concepts: JOINT PRODUCTION; RESPONSIBILITY; POWER OF JUDGEMENT; EVOLUTION; BASICS OF TIME; ENVIRONMENTAL

1. History

The phenomenon of ignorance was a central issue examined in Greek philosophy. Plato (428/427 – 348/347 B.C.) dealt with it in his early dialogues (e.g. Meno). According to the Oracle of Delphi, Socrates was acknowledged as the wisest of all human beings because he said, 'I know that I know nothing'.

Augustine (354 – 430), one of the great theologians and philosophers of the late antiquity, made himself aware of his ignorance by stating: "What, then, is time? I know well enough what it is, provided that nobody asks me; but when I am asked what time is and try to explain it, I am baffled" (Augustine 1961: 264).

One of the most important philosophers at the end of the Middle Ages was Nicolas von Cusa (1401 – 1464) who (1964: book II: 93, paragraph 162) "postulated an attitude of 'Docta Ignorantia' (doctor of ignorance, our translation). This meant the acknowledgement of the circumstance that all human knowledge emerges out of ignorance, and after some time may vanish or be replaced by new types of knowledge. For him the criteria for true science were an adequateness to everyday experience, openness, creativity and flexibility. From this point of view, he criticised, some decades before Copernicus (1473-1543), the geocentric world view of the ancient philosophers with the argument that they lack the 'Docta ignorantia', ignorance which is recognised and open to learning and alternative models. The concept of 'Docta Ignorantia' includes the faith that human thinking and action spring from a dimension which is greater than human knowledge and which can be experienced only in humble acknowledgements of our ignorance" (Faber et al. 1998: 228-9).

At the beginnings of modern science, the problems of knowledge and ignorance had long been analysed, especially by Kant (1724 – 1804). "Two hundred years ago he saw the following as fundamental questions of philosophy (Kant 1956: 677 B 833, our translation): *What can I know? What shall I do? What can I hope for?* Especially important for scientists in general, and ecologically orientated scientists in particular, is the question 'What can I know?'. The answer to this question is the basis for the questions 'What can we control? What possibilities of action do we have? What can we do?'. In the search for control of the natural world and protection against environmental damage, one usually concentrates on these three latter questions. Conversely, the first question 'what can I know?' has all too often been ignored by modern science.

Hayek (1899 – 1992) (1972: 33; our translation) has formulated this insight tellingly: 'Perhaps it is only natural that the circumstances which limit our factual knowledge and the

ensuing limits to applying our theoretical knowledge go rather unnoticed in the exuberance which has been brought about by the successful progress of science. However, it is high time that we took our ignorance more seriously'" (Faber et al. 1998: 205-206).

It was already Kant (1956: 295) who stated that the region of possible knowledge is rather limited: It "is like an island surrounded by a wide and stormy ocean which is the actual site of semblance and illusion (Schein)."

One of the most prominent researchers of the phenomenon of ignorance is Michael Smithson (see e.g. Smithson 1988). Concerning Ecological Economics, Funtowicz and Ravetz (e.g. 1990) have done pioneering work on the relevance of ignorance.

2. Theory

In general, environmental issues evolve over the long-term. The longer, however, the time scale [see concept BASICS OF TIME; Faber and Proops 1998: 140-142; Klauer et al. 2016] is, the more probable it is that we are confronted with surprises and hence with our ignorance. This concept "offers an analysis of surprise and ignorance in the context of environmental issues. Now it seems to us unfeasible to develop 'a general tool for the operationalisation of ignorance' (Funtowicz and Ravetz 1990: 7), particularly for the area of environmental problems. In contrast to this endeavour, we feel that the first task has to be to recognise the whole range of human ignorance. In order truly to understand this ignorance, we cannot confine ourselves to the field of environmental questions, rather we attempt to develop a general taxonomy of ignorance and surprise. This will lead us to a high level of abstraction, well beyond any particular problems. Hence the following considerations are widely philosophical and seemingly far away from environmental issues. However, we feel that a deepened understanding of ignorance will be helpful in gaining a new attitude towards environmental problems: an attitude of openness and flexibility instead of an attitude of control and inflexibility" (Faber et al. 1998: 205).

To deal with the concept of ignorance at length, philosophy offers many possibilities. It will turn out that there are so many forms of ignorance that we need a taxonomy of this concept. We start by examining the boundaries between knowledge and ignorance in Section 5.2. This leads us to differentiate between the concepts of risk, uncertainty and ignorance in Section 5.3. A major distinction between forms of ignorance is

- between ignorance within the objects of our scientific knowledge, i.e. concerning phenomena, and

- ignorance within our scientific statements about these objects, i.e. concerning our way of thinking.

What conclusions can be drawn from our analysis? Three key concepts are openness of mind (Section 2.4), freedom and will (Section 2.5); all three are crucial when dealing with ignorance.

2.1 Boundaries between scientific knowledge and ignorance

What are the boundaries between what we can know scientifically (see for an extensive discussion of scientific knowledge, everyday knowledge and wisdom Faber and Manstetten 2010: Chapters 4 to 6) and what we cannot know, i.e. when are we confronted with our ignorance? To answer this question, we start by noting that scientific knowledge is generally regarded as the most genuine form of knowledge, granting us certainty and revealing truth. Among the various sciences, the natural sciences are regarded as the most reliable for they alone combine mathematical stringency with the precision of the experimental process. For this reason, the institution of the Nobel Prize was originally reserved for the natural sciences alone. On the strength of the argument that the economic sciences meanwhile share the same stringent mathematical approach, a Nobel Prize for this discipline was established in 1969. If one wishes to examine the boundaries and limitations of scientific knowledge, it makes sense to stick to the natural sciences, where the merits of the scientific approach are particularly evident, its limitations can also be made more visible.

Transforming ignorance by learning and research into knowledge

There are boundaries which divide the field of scientific knowledge from that of ignorance (see Faber, Manstetten, Proops 1998: Chapter 11). These boundaries can seem somewhat flexible, at least when applied to certain types of ignorance. Everything which we do not yet know but can know and hope to one day know lies beyond the boundaries of knowledge but will one day be located within it. On an individual, personal level, the process of transforming ignorance into knowledge is called ‘learning’. The scientific community’s process of gaining knowledge is called ‘research’. Learning and research expand the boundaries of our knowledge. Our ignorance, however, does not seem to decrease in the process – indeed, through new discoveries we often realise that we know much less than we previously believed.

But ignorance that can be transformed into knowledge through learning, and research is only one part of the field of ignorance, namely that part which we know in principle how to deal with. This part lies at the borders of our knowledge, close to its limits. There are, however, other forms of ignorance which are fundamentally inaccessible to the scientific approach.

2.2 Risk, uncertainty and ignorance

To accentuate their distinctiveness, we will follow the differentiation between the categories 'risk' and 'uncertainty', introduced into scientific debate by Frank Knight (1875 – 1972) (1921), and supplement them by adding the category 'ignorance'.

We would like to illustrate this with an example: Someone who is often a spectator at horse races enjoys making bets on the triumph of this or that horse. Structurally there are two things which must be considered. (i) Any horse which participates can win. (ii) The (subjective) probability of winning varies from horse to horse. This probability is derived from the subjective experience of our spectator – 'this horse has already won many races' – and perhaps from his sense or intuition for the form of a particular horse on a particular day. In the case of a bet, our spectator knows all possible outcomes and can assign a certain probability to each one. Whenever all possible outcomes are known, and can each be assigned a subjective probability, we speak of 'risk' (see also Faber, Proops 1998:113f).

Let us imagine a second case. Since our racing fan does not pay regular attention to the weather reports, it can occur that he arrives at the race course only to discover to his surprise that the race has been cancelled owing to bad weather. He might have been aware of the outcome 'no race' as a possibility without him having assigned a subjective probability to it. Wherever possible outcomes are known but haven't been assigned a subjective probability, we speak of 'uncertainty'.

Now let us imagine a third case. After an extended period of absence from his home town, our race enthusiast returns and resumes his hobby. He goes to the race course or, more precisely, to where he expects the race course to be. Instead of the race course, however, he finds to his greatest surprise a supermarket at that location. This possibility simply did not enter into his considerations. Georg L. S. Shackle (1903-1992) characterises this case as follows: "What actually happens can have altogether escaped his (the individual´s, the authors) survey of possibilities, so that the degree of potential surprise he assigned to it was neither zero nor greater than zero, but was non-existent, a sheer blank" (Shackle 1955: 58).

Whenever actually occurring outcomes are not consciously existent beforehand, even as a potentiality, we speak of 'ignorance'. The events of September 11th, 2001 most likely belonged for most people to the field which we are calling ignorance, whereas the perpetrators who knew of their own plans were dealing with risk.

An example of ignorance in the field of environmental problems is the hole in the ozone layer: In the Thirties, when people began to use huge amounts of chlorofluorocarbons as a coolant in freezers and refrigerators, no one entertained the possibility that the Earth's ozone layer might be damaged. When this fact became public knowledge in the seventies and particularly in the eighties, it was a shock for everyone (See Luhmann 2001, Faber, Manstetten, 2007, Chapter 10).

2.3 Several forms of ignorance

Let us turn in greater detail to several forms of ignorance which are of significance to the scientific approach. We have, in a manner of speaking, (i) ignorance within the objects of our scientific knowledge and (ii) ignorance within our scientific statements about these objects.

Both forms of ignorance can be decreased in many points, but in both cases, it is never possible to transform the ignorance entirely into uncertainty or risk, let alone into scientifically certain knowledge. It must at this point be noted that, from the viewpoint of modern physics, all scientific statements hold at best with a very high probability, so that regarding their accuracy they belong to the category of risk (see Faber, Manstetten, Proops 1998: 224f). There always remains a certain indissoluble remnant of ignorance.

Ignorance within the objects of our scientific knowledge

To (i): We turn firstly to the concept of ignorance within the objects of our scientific knowledge. The scientific approach explains processes by referring them to laws. If we have, for instance, correct data in regard to the initial conditions of a mechanical system, we can predict all subsequent processes. It would seem that if we knew all the laws of nature and had all the relevant data, we could predict the course of all events. The French mathematician, astronomer and physicist Pierre Simon de Laplace (1749 – 1827) developed the ideal of an omniscient intelligence along these lines, the so-called Laplace demon (Laplace 1996, Introduction). This was conceived as an intelligence that knew all the laws of nature and was informed in regard to the position and velocity of every particle in the universe. According to Laplace's assumption, it would be possible for this demon to

predict all future states of the universe on the basis of his knowledge about the initial conditions and the laws of nature. The belief that human science can approach the ideal of such a demon has meanwhile been refuted by discoveries in modern physics and biology which show that there are processes which are principally unpredictable.

In physics these are the so-called chaotic systems. How such systems develop is not precise, sometimes even completely unpredictable. They do adhere to known natural laws, but an infinitely small deviation in the measurement of the initial condition leads to a completely different prediction as to what actually occurs. The weather can be taken as an example for such a system. The German weather can be viewed (as one physicist provocatively formulated it) as crucially dependent on the beating of a butterfly's wings in Peking. Seemingly tiny causes beyond any conceivable measurement can lead to the largest effects within such a system (To this see Lorenz 1963 and the excellently popular-scientific portrayal of Gleick 1988).

In biology, unpredictability can be found within evolutionary contexts where genetic mutation can lead to the emergence of new species [EVOLUTION; BASICS OF LIFE]. Since such mutations emerge under the influence of chance, they cannot be predicted. In other words: When novelty can arise within the framework of natural laws, predictions are impossible. The emergence of novelty is synonymous with the impossibility of a scientific prognosis. Even armed with all possible data concerning the stock of species a hundred million years ago, no scientist could ever have scientifically predicted that human beings would appear on Earth – indeed, there would have been nothing within that data from which one could have derived what a human being even is. Only someone who knows human beings because they exist could in hindsight (ex post) postulate that the potentiality for the appearance of humankind must have been principally derivable from the data of a hundred million years ago.

We will call the ignorance concerning objects phenomenological, irreducible ignorance (see Faber and Proops 1998: 121 ff.).

Ignorance within scientific statements

To (ii): We come now to the concept of ignorance within our scientific statements about phenomena. Here again we find two aspects. The first is the status of the primary fundamentals of a science: the axioms. These must be accepted without having been proven: They are the foundations of the statements derived from them but cannot themselves be derived from other statements within the framework of the respective science. In adherence to the systematics of science itself, the truth of our most fundamental assumptions eludes the scientific method of argumentation and proof. This does not

exclude the possibility of proving the axioms of a certain science within the framework of another science. But the other science, whatever it might be, is also based on axioms, so that at some point we will finally encounter axioms which we cannot prove. The scientific approach extends to the procedure, but the preconditions for both the logical deduction and the experimental method are a given, something which cannot be proven with scientific certainty within the procedure itself. As past attempts at putting axioms on the non-derivable and irrefutable of apperception a priori insights of reason always remained controversial, modern science generally assumes that an axiom can be considered valid as long as the statements that are constructed upon it - though falsifiable - have not been refuted. In this sense, however, the axiom that the Earth is the stationary centre of the universe would not be incorrect as far as statements in regard to the solar system are concerned – that form of astronomy, which was named after its founder Ptolemy (83-161 BC) and found use before Copernicus (1473 – 1543) and Kepler (1571 – 1631), was able to make good predictions on the basis of that axiom. The axiom employed later, which claimed that the Earth revolved around the (stationary) sun, merely had the main advantage that it led to considerably simpler models for the movements of the planets than the old model did.

Difficulties of a very special kind arise from a second form of ignorance within our scientific statements: We are referring here to the ambiguity of language and the pragmatic problems of understanding and comprehension. All empirical sciences contain more than laws and data: They contain interpretations of data in regard to laws. Even the most mathematical treatise in physics or economics contains interpretations which must make use of everyday expressions. This element of interpretation within science, often underestimated, entails that unambiguousness is not always automatically a given within scientific statements. At best, such unambiguousness can only be approximated within a process of communication. Scientists among themselves (even those in the same or similar fields) as well as scientists and members of an interested public often do not understand one another at all. Frequently, within one and the same discipline contrary viewpoints exist regarding the meaning of a certain term within the context of a concrete statement. This is especially the case in regard to many fundamental terms: It cannot be unambiguously clarified what ‘entropy’ [THERMODYNAMICS] or ‘chance’ means in physics, and the same goes for ‘evolution’ [EVOLUTION; BASICS OF LIFE] and ‘fitness’ in biology, ‘environment’ in ecology, and ‘utility’ or ‘optimality’ in mathematical economics [INTRODUCING MINE; HOMO OECONOMICUS & HOMO POLITICUS]. In many cases, scientists do not even notice that they are referring to different things in the same terms, as they are not conscious of how essential the clarification of semantics is for the understanding of their results. If they did, they would recognise the inevitable (sometimes not insignificant) residue of ignorance

which is entailed by the fact that science for fundamental reasons remains bound to the umbilical cord of everyday language. Attempts to cut the cord with ultra-precise definitions result in a truly insoluble confusion of language. Almost everyone has had the experience when participating in discussions about environmental issues that those involved are completely talking past one another, often in the belief that what they are saying is perfectly clear. Independent of our level of scientific knowledge, the communication problems both within a discipline and between science and the public can lead us to being ignorant in an area where we urgently desire to know something, and really should be able to know it.

We will call the ignorance concerning our scientific statements epistemological, irreducible ignorance (see Faber and Proops 1998: 123-124).

From ignorance to openness

What have we learned from our considerations so far about knowledge, surprise and ignorance? The main conclusion is that we have to become aware of different forms of ignorance. In particular, we have to become aware that we will always be confronted with the question as to what is going to happen, be it in everyday life or science. With an awareness of this state of affairs, it is useful to remember "that philosophy involves the study of knowledge, as implied by its literal meaning, i.e. 'love of wisdom'. But great philosophers of all periods have recognised that to understand knowledge one also has to understand ignorance. We noted above (see Section 1 above) that Kant said that the region of our knowledge is like an island 'surrounded by a wide and stormy ocean which is the actual site of semblance and illusion'. This ocean of pretended knowledge is in truth the ocean of our ignorance" (Faber and Proops 1998: 133).

But truly recognising ignorance "includes the faith that human thinking and action springs from a dimension which is greater than human knowledge and which can be experienced only in humble acknowledgement of our ignorance.

One main intention of Kant's *Critique of Pure Reason* (1956: 33; B XXX, our translation) is expressed in the following sentence: 'I had to eliminate knowledge to gain room for faith'. Faith in Kant's sense does not mean the adherence to any church or confession, but an attitude of openness and confidence towards all matters which lie in the area of our ignorance. Kant's ethics were offered as an attitude which is not only valid for known circumstances and tendencies, but also for the unknown.

The attitude of openness as described by Plato, as well as by Nicolas of Cusa and Kant (see Section 1 above), can be seen as the essence of philosophy and knowledge. This

attitude allows humans to experience all things as they develop, not as we might prejudge them, but accepting them as they are" (Faber and Proops 1998: 134).

Freedom and will

"At first sight, the conclusion of our anatomy of surprise and ignorance may seem to be negative. Our attempt to give an answer to Kant's first question 'what can I know' (i.e. of knowledge) has shown that there are inherent narrow limits to human knowledge. This implies that there are limits to purposeful activity, too. Also, the attitude of openness, which was described above the previous sections, is not active but passive: An attitude of openness implies being prepared and waiting, like the virgins in the New Testament (Matthew 25: 1-12).

However, this seeming passivity is only one aspect of our conclusions. We remind the reader of Kant's second question 'What shall I do'. The answer to this question, in the sense of Kant, is in its essence not determined by our knowledge or by our ignorance. Kant's approach refers rather to human freedom which is essentially not affected by knowledge or lack of knowledge. Of course, different concepts of freedom exist in philosophy. For instance, Greek philosophy finds that human beings are free to act according to the order of the cosmos. In terms of Kant, one may say they are free to act according to the moral law which exists within them. If this or any other kind of freedom is recognised, then one can act according to it if one *wants* to do so. That means one must make a corresponding *decision,* one has to formulate a *will* [JUSTICE & SUSTAINABILITY*,* Section 6.4]. This will then be an orientation for acting in general and for politics in particular. Of course, the will cannot be formulated once and for all, but there has always to be a continuous *decision* to keep up the will or to reformulate it. It is important to note that the object of the will may change when there is new information. However, the orientation of the *free will* is unaffected by new information and new concepts. This is so because the orientation is towards a moral law which cannot be changed, not even by new information" (Faber and Proops 1998: 134f). [Readers who are interested in the relationship between this argumentation and the concept of practical wisdom or practical judgement we refer to POWER OF JUDGEMENT, in particular Section 2.1 and RESPONSIBILITY, in particular Section 2.1.]

"The greater the time span [BASICS OF TIME], the greater the ignorance one has to cope with, hence the greater the significance of the will as a compass for acting. Since environmental problems are long-term in nature, we consider the will to be of utmost importance for their solution" (Faber and Proops 1998: 135, see also Klauer et al. 2017).

Will confronted with wish

"To clarify the meaning of our concept of will, it is useful to confront it with the concept of wish. For instance, in many western countries, particularly in Germany, there is the wish to have a better environment, to use less polluting industries, to produce less waste etc. Nevertheless, no really drastic policy measures have been taken which would lead to corresponding environmental activities. This is so because in society there exists only the *desire* for environmental protection and not the will, for the latter would require the determination to carry through drastic policy changes, with all of their consequences such as unemployment in certain industries, reduction in growth rates, restrictions in the freedom to move, etc. Thus, the main difference between the wish and the will is that the latter implies that people are willing to take into account [INDIVIDUAL, COMMUNITY & ENTIRETY] and to endure all the frictions, the strenuous efforts and sufferings which the wish entails [JOINT PRODUCTION]" (Faber and Proops 1998: 134-135).

3. Practice: Ignorance and Joint Production

The previous elaboration on the concept of ignorance was rather philosophical and abstract. For this reason, we want to illustrate it concretely with a relationship which is of fundamental relevance for the state of the environment. To this end in Section 3.1, we turn again to the circumstance that production and consumption have repercussions for the state of the environment, as described in JOINT PRODUCTION [see also THERMODYNAMICS]. There we showed that production does not only have side-effects, but that the side-effects are often unknown [JOINT PRODUCTION, in particular Section 3.3]. As was explained there in the example of the development of the soda-chlorine sector, intended and un-intended joint products exist. In particular, many environmental problems arise from the fact that the un-intended joint products are often unknown. We will thus turn to this problem in more detail in Section 3.1. Thereafter we will develop a classification of different forms of ignorance. This will enable us to gain new insights on the Precautionary Principle, which we will address in Section 3.3 below.

3.1 Joint products and consequences

We will begin by having a closer look at characteristics of joint products.

“With respect to the joint products emerging from a production activity, let us make a threefold conceptual distinction. Joint products can be classified into identified and unidentified joint outputs.

With regard to the identified joint products, we can (ii) distinguish between identified and unidentified consequences or effects of these outputs. Additionally, as has been discussed extensively in [Joint Production], joint products (and their consequences) can be (iii) divided into desired and undesired joint products (and consequences).

Whereas the distinctions (i) and (ii) are made on a basis of purely factual knowledge, distinction (iii) is an economic one involving the valuation of outputs and consequences. Distinction (iii), hence, requires normative knowledge. An example of a desired joint product would be mutton which arises as a joint product of wool. In contrast, an example for an undesired joint product would be dioxin arising from the burning of waste.

Knowledge and ignorance are relevant for these distinctions. With regard to the first two distinctions, the relevance is so explicit as to be almost trivial: Identified joint products and consequences belong to the domain of knowledge, while ignorance exists with regard to unidentified joint products and consequences. This is a matter of factual knowledge.

At first glance, the problem of ignorance does not seem to arise with regard to the question of the desirability of products. However, distinguishing between desired and undesired joint products also raises a problem of knowledge. This link is less obvious, but possibly more significant. Regarding oneself, one may assume, that one knows for oneself whether one desires something or not. Hence, one would presumably also be expected to know whether one prefers the existence of a product to its non-existence or vice versa. Such knowledge does not exist, however, when one takes the dimension of time into account. Ambivalence of joint products tells us that outputs which are desired today may later become undesirable (or vice versa). An example is meat, which is desirable for human beings who eat meat until they change their mind and become vegetarians.

Recall that a transition of a product’s desirability – from desired to undesired or vice versa – can arise for a number of reasons. It can be due to the discovery of previously unidentified effects which may be perceived as positive or negative. It can be the result of a shift in preferences. It can result from technological change.

Such a transition in the desirability of a joint product can generally not be foreseen (see Baumgärtner et al 2006: Chapter 16: Chlorine: Innovation and Industrial Evolution and EVOLUTION). At any time, therefore, a certain ignorance exists with respect to the future character of joint outputs as being desired or undesired. A central question with respect to this ignorance is, however, whether or not it is possible to transform this ignorance into knowledge ex ante.

With regard to joint production, we find ourselves confronted with two forms of ignorance. The first concerns factual knowledge about joint products and their consequences, and the second concerns normative knowledge about the desirability of joint products.

Factual knowledge about joint products and consequences

We first examine unidentified joint products and consequences –the latter being consequences of identified or unidentified joint products. We have conceptualised a joint product as a necessary concomitant of a certain production process [JOINT PRODUCTION]. With regard to joint production and its consequences, we are therefore dealing with scientifically identifiable correlations.

These correlations can, in principle, be known. That which hinders us from knowing all these things, and the interrelations between them, however, is the limit of our means of perception, our inattentiveness, as well as the difficulties of communicating the knowledge a society has accumulated to separate research institutions and individuals. Viewed in this manner, the hole in the ozone layer and global warming due to greenhouse gases should not have come as a surprise: Each would have been completely predictable, given a certain research effort and scientific capabilities.

With regard to identified joint products and the effects of joint products, knowledge is available, but also limited. We can, however, keep moving the borders between knowledge and ignorance further and further into ignorance's domain. We are able to continuously transform ignorance into knowledge, even if we cannot hope to ever finalise this process.

Normative knowledge about the desirability of joint products

The situation is different with regard to the desirability or undesirability of joint products. Let us again examine the three aforementioned reasons for the transition of a product's desirability at the end of Section 3.1.

To 1. Previously unidentified effects: Concerning the first reason, the desirability of products and joint products can be modified by the discovery of formerly unknown corollaries of these outputs. In this respect, the desirability of outputs seems to depend solely on scientifically observable facts. But this is misleading. Whether something is desirable or not is the outcome of a social valuation process which involves complex social interaction. Hence, the desirability of products does not exclusively depend on existing physical circumstances, but also on, e.g. whether and when these circumstances become known to the members of society. Such a potential future recognition of presently unknown circumstances by society is not completely foreseeable in the same manner as the joint

products themselves. An example is the pure chlorine which was employed in more and more applications not foreseen [JOINT PRODUCTION, Section 3.1]. This holds in particular for the development of the CFCs, the chlorofluorocarbons in 1870 and produced on a large scale only in the early 1930s.

To 2. and 3. A shift in preferences and introduction of new technologies: The same is true for reasons 2 and 3 – a shift in preferences or the introduction of new technologies. In both cases, hardly any ex ante predictability exists. New technologies derive from inventions and these are, by definition, not predictable. This holds equally for the shifting of preferences. Shifts in preferences, just as inventions, must be conceived as free results of human spontaneity. Shifts cannot be directly derived from the circumstances of their emergence. A shift in preferences, as well as an invention, has some characteristics of novelty and originality. The same applies to the progress of human knowledge about nature's causality. Knowledge and its progress, as well as the shifting of preferences and inventions, are not phenomena of nature, but of the mind. Not only do they restrict our prognostic knowledge in the way the complexity of nature's causality does, they also give our prognostic knowledge distinct borders. Such intellectual phenomena are a source of causality on their own and cannot become the object of prognostic knowledge" (Baumgärtner et al. 2006: 242-245).

3.2 Categories of ignorance

"Let us recapitulate. While we can investigate unidentified joint products and the unidentified consequences of joint products ever further, we find ourselves faced with insurmountable obstacles when it comes to foresight. These reflections on the possibilities of knowledge can be related to the problem of responsibility. We have shown in RESPONSIBILITY that Friedrich Wilhelm Hegel (1770 – 1831) discussed the differentiation between the necessary and the chance consequences of actions. Following Hegel's differentiation, it is solely the necessary consequences, not the chance consequences, which one must assume responsibility for.

The phenomenon of joint production, however, casts a shadow over this for the following reason. The necessary consequences of joint production are the joint products themselves, along with all the consequences they entail – be they identified or unidentified. However, as we have argued above, nature's complexity suffices to make it impossible to truly take all necessary consequences into account – that is, every single joint product and each and every one of their consequences – for our knowledge is inevitably limited. It is a chance consequence of joint production whether a particular joint product is desired or not

and whether it will be so in the future, for the desirability of a joint product is only partly determined by physical correlations. Following Hegel, it would therefore be not necessary to assume responsibility for the desirability of joint products. Yet, whether a joint product is desired or not is actually a crucial aspect of whether or not one can assume responsibility for a specific production process or not. At this point, we thus see the limitation of a conception such as suggested by Hegel for the problem at hand.

In light of the significance of knowledge and ignorance for the acceptance of responsibility in the following, we elucidate several categories of ignorance and the dynamics of transforming ignorance into knowledge.

Categories of ignorance and the transforming of ignorance into knowledge

In a first differentiation, ignorance can be divided into closed and open ignorance. A person is characterised by closed ignorance when he does not know that he is ignorant. In other words, that person has no knowledge of his own ignorance. In the case of open ignorance, the person is conscious of his ignorance: He knows what it is that he does not know.

Open ignorance can be further differentiated according to whether it is reducible or not. Reducible ignorance may be individual and social ignorance. An individual can reduce his ignorance by learning; a society uses scientific research to transform its ignorance into knowledge. We want to subsume the knowledge which a society has accumulated under the expression social knowledge. The term social knowledge does not imply that each individual member of society has access to this knowledge. Contrarily, individual knowledge is always smaller than social knowledge.

If ignorance cannot be reduced as described above, we speak of irreducible ignorance. For example, ignorance may be irreducible because of the overwhelming complexity of the object of research; irreducible ignorance also stems from the continuous possibility that true novelty emerges.

Let us investigate the relationship of these categories of ignorance to the concept of joint production and to our previous reflections. In principle, the concept of joint production lends itself to the process of transforming closed into open ignorance. According to thermodynamic considerations, all (industrial) production is ultimately joint production [JOINT PRODUCTION]. Thus, the awareness of joint production demonstrates to the producer that every form of production necessarily entails joint production – that is, at least one joint product – and, moreover, also entails further effects. By that knowledge, the producer can actively attempt to reduce his ignorance implicit to joint production through learning; society can reduce its corresponding social ignorance through scientific research.

As demonstrated above, however, joint production also entails an element of irreducible ignorance. In fact, we are dealing with irreducible ignorance induced by both of the aforementioned reasons:

The complexity of scientifically researchable natural causality often makes it impossible to identify all joint products and every one of their effects.

And whether a joint product is desirable or not in the long run depends on phenomena with the characteristic of novelty, namely changes in preferences and technological inventions. Thus, ignorance with respect to the desirability of joint products is not completely reducible (see Baumgärtner et al. 2001: 369).

Knowing that irreducible ignorance exists can have an ambivalent effect. It can cause us to take greater care. On the other hand, it can also have the opposite effect in that it can lead us to irrationally allow ourselves to be guided by a 'principle of hope' (Bloch 1959) after all. This is to say that we, faced by evidently unsolvable problems with regard to undesired joint products or their dangerous consequences, choose to depend upon future discoveries to solve these problems and alleviate the dangers brought about by our actions today" (Baumgärtner et al. 2006: 245-247).

3.3 The Precautionary Principle

How shall we deal with irreducible ignorance? This is fundamental problem of environmental policy. The first one who dealt in a fundamental way with this question was the philosopher Hans Jonas (1903 – 1993). He offered an answer by introducing a 'heuristic of fear' which is closely related to what after the publication of his pioneering monography was developed as the precautionary principle.

We noted in the concept RESPONSIBILITY, Section 2.7, that we have not yet dealt with the Precautionary Principle and that we would postpone this discussion to the present concept IGNORANCE. The reason for this approach is that the concept of ignorance is a precondition for a thorough analysis of the Precautionary Principle, for this principle confronts us with the enormous complexity and unpredictability of environmental problems. In the following, we first deal with Jonas' (1979) analysis. There is, however, a general agreement in the literature that the Precautionary Principle still lacks a sound conceptual foundation. We believe, however, that our analysis of ignorance might be of some help in this respect. To this end, we want to combine our analysis of ignorance and, joint production with the Precautionary Principle by taking recourse to the concept of *power of judgement* [POWER OF JUDGEMENT]. This integration supplies an encompassing understanding of the

phenomena ignorance and joint production [JOINT PRODUCTION] and the precautionary principle and gives the latter a solid basis.

Jonas on ignorance and precaution

Considering "the modern environmental crisis, the problem of the distinction between necessary and chance consequences poses itself in a different manner. Jonas (1979) examines the demands which the modern environmental crisis burdens us with in his book *The Imperative of Responsibility* [RESPONSIBILITY] (all translations are ours). In light of the enormous ramifications of our technological activity, Jonas declares knowledge to be a 'most urgent obligation', and that this knowledge 'must be of equal dimension to the causal scale of our activity' (Jonas 1979: 28). This means that our knowledge must be able to keep up with the consequences of our activity. Such 'dimensional equality' is, however, all but impossible to achieve for the following reasons:

'the complexity of social and bio-spherical totalities which mock all mathematics; the unfathomable nature of mankind, forever lying in wait with surprises; and the unpredictability, the non-pre-invertibility of future inventions' (Jonas 1979: 66).

The demand for prescience of the consequences of our actions cannot be met in the modern industrial civilization. Thus, we must make do with knowledge regarding possible consequences (Jonas 1979: 67), if indeed we can foresee only a part of the actual consequences. Our guide should be a 'heuristic of fear' rather than a 'principle of hope' (Bloch 1959). We know far better what our worst evil is than our greatest good (Jonas 1979: 63).

What Jonas is proposing is a form of 'ethics of knowledge' under the restriction of inevitable ignorance. But what can we know and where do the limits of our knowledge lie? Jonas remains relatively ambiguous with regard to these questions.

The Precautionary Principle

The concept of joint production, however, allows us to define more precisely what degree of knowledge about the consequences can be achieved. At the same time, it can be used to demonstrate that the distinction between necessary and chance consequences discussed by Hegel no longer suffices for a determination of the limits of responsibility [RESPONSIBILITY]" (Baumgärtner et al. 2006: 241-242).

We now turn Jonas' heuristic of fear which, as mentioned above, is "closely related to the Precautionary Principle. The principle demands that one take precautionary measures to avoid harmful events, which are the object of fear. The Precautionary Principle is

notoriously difficult to define. A frequently cited definition stems from the Wingspread Conference in 1988 (Raffensperger and Tickner 1999):

'Therefore it is necessary to implement the Precautionary Principle: Where an activity raises threats of harm to the environment or human health, precautionary measures should be taken, even if some cause and effect relationships are not fully established scientifically.'

There is general agreement in the literature that the Precautionary Principle still lacks a sound conceptual foundation (e.g. Sandin 2004: 462, Turner and Hartzell 2004). In our view however, the proposal for a definition of the principle provided by Sandin (2004) can be used as a starting point. Sandin builds his argument on the premise that one can speak meaningfully of precaution only if one relates it 'to something' (Sandin 2004: 464). This implies that precaution is related not to general circumstances but always to a specific occurrence. It, hence, does not make sense to state that someone 'generally acts according to the precautionary principle'. Sandin (2004: 464–467) develops three criteria which an action must fulfil to meet the Precautionary Principle:

i. The criterion of intentionality, meaning that the action must be intentionally directed against the occurrence which is to be avoided.

ii. The uncertainty criterion, which demands that the occurrence to be avoided is not 'certain or highly probable' (Sandin 2004: 466).

iii. The reasonableness criterion, which demands that 'the agent has good reasons' that are fulfilled and, further, that the action 'will in effect at least contribute to the prevention of the harmful event' (Sandin 2004: 467).

Before proceeding, it is useful to remind the reader of the three types of ignorance – risk, uncertainty, and ignorance […]. As we noted, Knight (1921) speaks of 'risk' if the outcomes and probabilities of an event are known, and of 'uncertainty' if only the outcomes are known but not their probabilities. Faber et al. (1996c: 210) define 'ignorance proper' to be the 'inability to specify all future outcomes'.

Integrating an encompassing understanding of ignorance and joint production into the Precautionary Principle

Sandin's three criteria shall now be discussed in light of the previous considerations in Sections 1 and 2 above. In Sandin's conception, the Precautionary Principle relates only to the phenomena of risk and uncertainty. According to Sandin, the occurrence to be prevented by precautionary measures has to be known and must not be highly probable. Hence, ignorance proper, as defined above, is excluded from his considerations. Joint

production on the other hand – in particular in its general principle, giving rise to a high degree of complexity – implies that we cannot hope to know all possible outcomes of an event, neither in the present nor in the future [JOINT PRODUCTION]. Moreover, it is important to emphasise that from the three types of ignorance defined above, ignorance proper is at the root of the most severe problems raised by joint production. For this reason, it is not adequate to restrict the Precautionary Principle to known events, i.e. to risk and uncertainty, as Sandin does.

From this, we derive the following two conclusions:

1. Precaution, as demanded by the Precautionary Principle, has to be precaution in general, not only towards specific events.

2. Humans exercising precaution are confronted with ignorance and, as we have shown in Section 2.6, they are confronted with irreducible ignorance" (Baumgärtner et al. 2006: 247-249).

What follows from these amendments? To this end we have to take recourse to the concept POWER OF JUDGMENT.

The Precautionary Principle and the power of judgement

"Responsible action under conditions of ignorance (proper) requires the power of judgement [POWER OF JUDGEMENT]. The power of judgement is implicitly addressed by Sandin (2004: 467) when he refers to 'good reasons' in criterion (iii). These good reasons are not 'objectively good' since they cannot be demonstrated by scientific methods, but they can only be 'somehow externally good', i.e. they must be judged by others to be good reasons. To refer to the judgment of others is – as Kant (2000: 173f) has pointed out – a specific capability of the power of judgment, which he calls *sensus communis*:

Yet sensus communis must be understood as the idea of a communal sense, that is, a faculty of judging that in its reflection takes account (a priori) of everyone else's way of representing in thought in order, as it were, to hold this judgement up to human reason as a whole and thereby avoid the illusion which, from subjective private conditions that could easily be held to be objective, would have a detrimental influence on the judgement (Kant 2000 [1790]: 173 f).

Power of judgement is also employed by practical wisdom – *phronesis* in terms of Aristotle. Insofar as precaution is related to practical purposes, it requires phronesis, i.e. the practical power of judgement [RESPONSIBILITY, Section 2.4). Responsible behaviour is a virtue if we are, at least partially, ignorant of the possible consequences of our actions. It is precisely

this virtue which is demanded by the Precautionary Principle" (Baumgärtner et al. 2006: 249).

Conclusion

"The Precautionary Principle is a universal principle which concerns all possible consequences of one's actions. Although specific precautionary measures must be related to certain known outcomes, the principle itself cannot be restricted to known occurrences. [RESPONSIBILITY, Section 2.1). Only if one is responsible for something or someone in particular must one act with precaution in that respect. Furthermore, since precaution demands the power of judgement [POWER OF JUDGEMENT] and phronesis, it cannot be solely based on science. For this reason, the definition from the Wingspread Conference (Raffensperger and Tickner 1999, see above) states that 'precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically'" (Baumgärtner et al. 2006: 247-249).

From this follows that precautionary action demands that it cannot be based solely on scientific expertise, but it needs a capability beyond science. Contemplating ignorance from this point of view leads to an attitude of openness. The circumstance that different "forms of ignorance can emerge within a scientific field or even within scientific statements themselves does not denigrate the scientific approach. What is problematic is only an attitude within science, politics and society that entrusts science with the solution of all problems – in combination with technology – even with the very salvation of the human race (see Faber and Manstetten 2010: Chapter 7). If we do not know when we are ignorant, if we believe we have certainty where many things are uncertain, if we believe we are proceeding on firm ground when we should be stopping and examining our footing, then our ignorance is at its greatest. In these instances, ignorance becomes an expression of arrogance, making us overly self-confident, blind and narrow-minded. It conjures up illusory perspectives in the distance instead of causing us to see what we can and should see in our vicinity. It is a sign of wisdom not to consider oneself wiser than one is. This insight into and acceptance of our ignorance should be assimilated into our actions" (Faber and Manstetten 2010: 38).

4. Literature

The content of MINE originates from scientific work published in books and peer-reviewed journals. Quotes are indicated by a special typographic style.

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The main sources of this concept are the following publications:

Baumgärtner, S., Faber, M. and Schiller, J. (2006), Joint Production and Responsibility in Ecological Economics. On the Foundation of Environmental Policy. Edward Elgar, Cheltenham.

Faber, M., Manstetten, R., Proops, J.L.R. (1998), Ecological Economics. Concepts and Methods. Edward Elgar, Cheltenham.

4.1 Recommended literature

Key literature

Baumgärtner, S., M. Faber, J. Schiller (2006), Joint Production and Responsibility in Ecological Economics. On the foundations of Environmental Policy. Edward Elgar, Cheltenham/Northampton. [The book examines the relationship between IGNORANCE and JOINT PRODUCTION].

Faber, M., Manstetten, R., Proops, J.L.R. (1998) Ecological Economics: Concepts and Methods, Edward Elgar, Cheltenham [Chapter 11 forms the basis of this concept.]

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