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Uncertainty: Cause or effect of stakeholders' debates? Analysis of a case study: The risk for honeybees of the insecticide Gaucho®

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Abstract

The social construction of uncertainty plays a major role in environmental decision-making. Methods for assessing this aspect of scientific knowledge quality are lacking. Our analysis of the French debate on the risk that the insecticide Gaucho® (active substance: imidacloprid) forms for honeybees is particularly relevant to this theoretical and practical gap. Based on our analysis, we propose six knowledge quality criteria that can assist in assessing the information communicated in an argumentative public process: reliability of the information – it must be based on all available scientific knowledge; robustness of the information – it must take into account criticism; use of the information produced by other stakeholders; relevancy of the arguments for issue under debate; logical coherence of the discourse; and legitimacy of the information source. Further, our findings deepen the understanding of the relationships between the social, economic, and institutional stakes of the actors involved in the debate and their strategies of 'creating uncertainty'. Finally, we compare the findings of this case study with the twelve lessons drafted by the European Environmental Agency (EEA) in its report *Late lessons from early warnings*, and we draft two more lessons. These lessons can be applied to future policy in order to minimize the repetition of past mistakes.
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1. Introduction

The history of the governance of Gaucho®'s risk with regard to honeybees provides insight into the functioning patterns of the knowledge society. Based on an analysis of the French controversy on Gaucho®, this paper explores the relationships between the production and use of scientific knowledge and the socioeconomic stakes present in risk governance.

Empirical and theoretical studies on the role of science in risk governance challenge the view that scientific research informs policy by producing objective, valid, and reliable knowledge (Ravetz, 1971; Funtowicz and Ravetz, 1993; Wynne, 1992; Nowotny et al., 2001; Irwin, 2001; Walker et al., 2003; Funtowicz and Strand, in press). New scientific practices, coined post-normal science (Funtowicz and Ravetz, 1993), are now required in the context of hard political pressure, disputed values, high decision stakes, and major epistemological and ethical system uncertainties. The main features of post-normal science are the appropriate management of uncertainty, acknowledgment of the

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plurality of problem perspectives, and the extension of the peer community to include non-scientific actors.

A further complication today is that more and more actors (industry, academia, NGOs, interest groups, non-scientific experts, investigative journalism, etc.) are producing knowledge relevant to risk decision-making. This makes it increasingly problematic to talk about 'science' (in general) and see its role as speaking 'truth' (the objective facts) to 'power' (decision-makers) (Wildavsky, 1979). Sociology of Scientific Knowledge (SSK) has shown that the social, economic, and institutional stakes that form the context in which knowledge is produced, used, and interpreted in discourses on risk governance are essential factors in understanding scientific controversies on risks (see, e.g., Jasanoff et al., 1995; Irwin, 2001). This constructivist view does not deny the importance of scientific evidence (Irwin, 2001), but stresses the key role that is played by the societal context in which the knowledge is produced and used.

The rationale of the present paper is that, in a situation of controversy and uncertainty about risk, the role of science can be strengthened by systematic critical reflection on both the scientific quality of risk evidence and the argumentative quality of the discourse which is intended to inform decision-makers. These two levels of quality are elaborated in the Structure and methodology section of this paper. The aim of the paper is to contribute to the development of tools for Knowledge Quality Assessment (henceforth KQA). These tools are essential for precautionary risk governance in order to achieve a timely and adequate policy response to early warnings of severe new risks (UNESCO, 2005; Van der Sluijs, 2007). In the same line, the European Environmental Agency (EEA) drafted twelve lessons (see Box 1) on precautionary risk governance, based on fourteen historic case studies (EEA, 2001).

The attention that scientific risk evidence receives from decision-makers strongly depends on the economic and social context in which the risk is identified (EEA, 2001). When the outcome of scientific risk assessment involves high economic and social stakes, the risk assessments can become tools for establishing the power balance in the political arena. We used the concept of 'uncertainty' to gain insight into the role of contextual factors in the quality of scientific evidence. Uncertainty here is understood in a broad sense. It refers to the situation that the body of evidence from scientific research is (perceived to be) inconclusive with regard to the magnitude and nature of adverse effects, the causal mechanisms, and the probability of a risk. Uncertainty has multiple dimensions: technical (inexactness), methodological (unreliability), epistemological (ignorance) and societal ((un)robustness) (Funtowicz and Ravetz, 1990). Tools available today (e.g., sensitivity analysis and Monte Carlo analysis; Saltelli et al., 2000, 2004) assess quantifiable dimensions of uncertainty (inexactness). In contrast, methods for the systematic assessment of qualitative uncertainty dimensions (such as value loading in knowledge production) are still in the early stages of development (Van der Sluijs, 1997, 2006; Kloprogge et al., 2005).

The dominant belief that inappropriate control of environmental risks is due only to insufficient scientific knowledge ignores the influence of political and societal contexts on risk governance (Wynne, 1992). Stakeholders can strategically use science in public

Box 1
Twelve 'late lessons from early warnings' (EEA, 2001)

A. "Broaden the Framing and Assumptions"

- Manage 'risk', 'uncertainty', and 'ignorance' [1]
- Identify/reduce 'blind spots' within disciplines [3]
- Assess/account for all pros and cons [6]
- Analyze/promote alternative options [7]
- Take account of stakeholder values [9]

B. "Broaden Assessment Information"

- Promote long-term monitoring/research [2]
- Identify/reduce interdisciplinary obstacles to learning [4]
- Identify/anticipate 'real-world' conditions [5]
- Use 'lay', local, and specialist knowledge [8]
- Ensure regulatory and informational independence[10]
- Identify/reduce institutional obstacles to learning [11]

C. "Act when there are reasonable grounds for concern"

- Avoid 'paralysis by analysis' [12]

The number between brackets refers to the numbering of lessons in the original EEA report.

debates (for example, by selecting information sources according to one's political agenda) and thus increase or distort scientific uncertainties (Hellström, 1996; Van der Sluijs, 1997, 2006). Moreover, the existence of contradictory expertise can be the result of a 'manufactured uncertainty', which is intended to favor the settling down and prolongation of the debate. This strategy can obstruct or delay decision-making and maintain an economic situation advantageous for certain stakeholders (Michaels, 2005). To explore the phenomenon of the social construction of uncertainty and its role in discourses on risk governance, this paper presents an in-depth analysis of the roles scientific evidence and social, economic, and institutional stakes have played in the vehement controversy in France over the past decade on the risks that Gaucho®, a systemic insecticide, forms for honeybees. This case is particularly interesting for the history of risk governance because it is the first time that the precautionary principle was applied in an environmental issue in France.

The central questions covered in this paper are:

- What is the relation between the strategy actors use to cope with uncertainty and their social, economic, and institutional stakes?
- What criteria are relevant for a systematic assessment of the quality of risk (scientific) evidence that is communicated in public controversies on risk governance?
- How does this case relate to the precautionary lessons (Box 1) listed in the *Late Lessons from Early Warnings* report (EEA, 2001)?

Systemic insecticides like Gaucho® (active substance: imidacloprid) comprise a new type of plant-protection product. They are employed in seed-dressing and/or soil treatment and disperse to all plant tissues during growth. This dispersal offers long-lasting protection to crops like sunflower and maize from pests including sucking insects and harmful soil insects (Elbert et al., 1991). It can, however, expose non-target insects like honeybees to the active substance through contaminated pollen and nectar. Moreover, the exposure of honeybees to imidacloprid is possible for long periods, especially during flowering (e.g., several weeks for sunflower and maize). The effects of the repeated consumption of contaminated pollen and nectar can appear either immediately or after several days or weeks (delayed effects), i.e., after they have first been stored inside the hive as pollen or honey. In this respect, systemic insecticides differ from the 'classic' sprayed insecticides, which are present on the plant for a shorter period (several hours or days after spraying).

Evidence of the risk caused by imidacloprid emerged when the substance's effects on honeybees were first studied in independent research (institutes and universities, funded by public money) in the late 1990s (for a compilation of results available at different points in time, see Scientific and Technical Committee for the Multifactor Study of the Honeybee Apiaries Decline, henceforth SCT, 2003). Political measures, however, were not taken until a long and vehement social debate enforced policy intervention. This debate involved beekeepers, Bayer (the company that produces Gaucho®), researchers, the French Ministry of Agriculture, farmers, and the civil society. This debate started in 1994 when beekeepers noticed symptoms that they had not previously observed: in several days of sunflower foraging, honeybee populations were suddenly and massively falling. The honeybees almost completely disappeared far from the hives or they were dying by the thousands in front of the hives. These mortalities were accompanied by behavioral symptoms specific for intoxication and by a 40–70% loss in sunflower honey yield (Abeilles/tournesol, 1997, 1998; GVA, 2006; Chambre d'Agriculture des Deux Sèvres, 2000; AFSSA, 2002; Alétru, 2003). Since Gaucho® was used for the first time in the treatment of sunflowers in 1994 and the symptoms were recorded for bees foraging Gaucho-treated crops, the beekeepers suspected a toxic effect of this product on honeybees. Consequently, they asked Bayer to inform them about the potential toxicity of the active substance for honeybees. This was the start of a long series of scientific studies involving experts from Bayer, the Ministry of Agriculture, beekeepers, and independent researchers. Some of the studies yielded arguments supporting and others refuting the causal link between seed-dressing with Gaucho® and the symptoms observed in honeybees. Still, other studies reported ambiguous findings.

The symptoms continued to be observed after 1994. Their regularity over the years, their specificity for bees foraging on sunflowers, and the geographical extent clearly differentiated them from symptoms observed before 1994 during accidental intoxications with sprayed pesticides. All of the studies undertaken by Bayer during this period reported that Gaucho® did not form a risk for honeybees.

This environmental problem quickly revealed social and economic dimensions: the sunflower honey harvest fell significantly and the economic status of many beekeepers was severely affected.

The combination of the research findings obtained by independent research (1998), social pressure, and media attention led to the first application of the precautionary principle for an environmental issue in France. In

January 1999, the Minister of Agriculture ordered a 2-year ban on the use of Gaucho® in sunflower seed-dressing. This ban was renewed in 2001 for 2 years and again in 2004 for 3 years. Bayer continued to state that the use of Gaucho® as a sunflower seed-dressing had no effect on honeybees (GVA, 2006; Parlement Wallon, 2004; Bayer Cropscience, 2006). The beekeepers and most of the media have accused Bayer of "*threats (…) and attempt of corruption*" (Libération, 9 October 2000), of dishonesty ("*Bayer attempted to cheat by presenting results that are not conform to the ones in the original reports a number of times to the Commission for Toxic Products*,[1]" (GVA, 2006)), and of reaping a profit at the cost of both the environment and public health. During that period, the Minister of Ecology and the civil society supported the beekeepers' arguments. The intoxication symptoms continued to be observed after the 1999 suspension of the use of Gaucho® in sunflowers. Two hypotheses were raised to explain this situation: (1) honeybees were still being exposed to the pollen of maize treated with Gaucho® and (2) imidacloprid persisted in the soils, i.e., the chemical was present in untreated crops growing in soil on which a seed-dressed crop had been grown one or several years earlier. In 2001, an interdisciplinary expert group, the Scientific and Technical Committee (SCT), was set up by the Ministry of Agriculture. Its objective was to assess the cause of the continuing decline in the number of honeybees.

Evidence confirming the risk that imidacloprid formed for honeybees accumulated from independent research in the years that followed. However, in 2003, the Minister of Agriculture decided not to ban the use of Gaucho® in maize seed-dressing. (Note: maize is one of the most economically important crops in France. Moreover, seed-dressing with Gaucho® significantly reduces the amount of work needed to protect the crop from insect pests, which makes the insecticide interesting to farmers.) Later that same year, the final report of the expert committee was published (SCT, 2003). It concluded that the risk imidacloprid formed for honeybees is worrisome, when Gaucho® is used to seed-dress sunflower and maize. Nevertheless, it was not until May 2004 that the Minister of Agriculture also banned the use of Gaucho® in maize seed-dressing. As an indication of the severity of the risk, the most recent risk assessment for honeybees collecting pollen from maize seed-dressed with imidacloprid, expressed as the ratio PEC/PNEC,[2] ranged between 500 and 600 (Bonmatin et al., 2005). Note that a ratio PEC/PNEC ≥ 1 is already equivalent to a risk (in this case, for honeybees).

Immediately after the Minister of Agriculture banned the use of Gaucho® on sunflower seeds, Bayer challenged the ministerial decision in the administrative court of Paris (March 1999). The case was passed onto the State Council (the highest administrative jurisdiction institution in France). About that time, several international consortia of seed producers (Monsanto, Novartis, Rhône-Poulenc, Pionneer, Maisadour, Limagrain) joined Bayer and formulated a similar case against the Minister's decision. The beekeepers, organized into the UNAF,[3] defended the Minister's decision in court. The State Council decided in favor of the beekeepers. Several other institutions were also called upon later to resolve the conflict: the Commission for the Access to Administrative Documents and courts all over France (where Bayer brought suit against several representatives of beekeepers' syndicates for discrediting Gaucho®).

The social tensions that accumulated during this ca. ten-year conflict are still present for two reasons. First, the position of Bayer has remained largely unchanged: "*… it is clear that seed-dressing products based on imidacloprid pose, at most, a very weak risk for honeybees*" (Bayer Cropscience, 2006). Second, imidacloprid is currently under evaluation by the EFSA (European Food Safety Authority) for inclusion on the list of active substances which may be marketed in the European Union.

2. Structure and methodology

The analysis of the Gaucho® controversy presented here comprises two interrelated parts. The first part (Section 3) analyzes the development of knowledge over time and the scientific controversies that emerged with regard to the risks evidence. The second part (Section 4) analyzes the economic, social, and environmental stakes underlying the stakeholders' discourses. These two sections address our first research question, i.e., what is the relation between the strategy the actors use to cope

[1] The 'Commission d'étude de la toxicité des produits antiparasitaires à usage agricole et des produits assimilés, des matières fertilisantes et des supports de culture' is a body working with the Ministry of Agriculture, usually abbreviated 'Commission for Toxic Products' or 'ComTox', that is composed of experts in toxicology and eco-toxicology. This body is in charge of the entire range of pesticide products. ComTox is charged with analyzing the authorization dossier from toxicological and eco-toxicological points of view.

[2] Predicted Environmental Concentration/Predicted No Effect Concentration.

[3] UNAF (Union Nationale de l'Apiculture Française) is one of the three of French beekeeping syndicates, representing about 22 000 beekeepers.

with uncertainty and their social, economic, and institutional stakes. Section 5 discusses the results of the analyses and answers the second and third research questions: ‘What criteria are relevant for a systematic assessment of the quality of risk (scientific) evidence that is communicated in public controversies on risk governance?’ and ‘How does this case relate to the precautionary lessons (see Box 1) listed in the *Late Lessons from Early Warnings* report?’. Finally, Section 6 summarizes the main conclusions of the paper.

Sections 3 and 4 are based on the idea that policy decisions made in a social context of scientific uncertainty and contradictory expertise are partly the result of the power play. In risk controversies, the ‘winning discourse’ plays a major role in determining how impacts are defined, how causes are established, and which solutions are chosen and implemented (Faucheux and Nöel, 1990). Analysis of scientific uncertainty and its management should include the sociopolitical context of stakeholders' actions. The paper, therefore, distinguishes two types of uncertainty (Van der Sluijs, 2006):

1. *Scientific uncertainty*, which may have both a quantitative (imprecision) and a qualitative (limitations of methods or incomplete state of knowledge) dimension.
2. *Social uncertainty*, which is determined by the quality of the expertise (directly related to competence, institutional dimensions such as the institutional affiliation, financial dependencies, and expert responsibility) and by the stakeholders' discursive strategies in selective use, framing, and interpretation of scientific evidence within the societal debate.

The framework used in Section 3 to analyze the scientific controversies distinguishes between (1) the accumulation of scientific evidence of risk over time and (2) the differences in significance that each element of the scientific evidence has for each of the stakeholders (beekeepers, Bayer, governmental departments, and independent research) in the social debate. The method used in this paper is discourse analysis. This type of analysis yields insight into the mechanisms that shape and frame social uncertainty and into the role of social uncertainty in risk governance.

Even if they do not share a single definition, discourse analysts agree that discourse is a form of language use that has to be studied in context (who uses language, how, why, and when) (Brown and Yule, 1983; Van Dijk, 1996, 1997a; Phillips and Hardy, 2002). In sociological tradition, our approach uses elements of critical discourse analysis (CDA), i.e., it analyzes “*real and often extended instances of social interaction which take a linguistic form, or a partially linguistic form*” (Fairclough and Wodak, 1997, p. 258). The CDA considers discourse as a form of ‘social practice’, whose description implies considerations about a two-way relationship: not only is the discursive event shaped by situations, institutions, and social structures, but it also shapes them. That is, the discourse constitutes the social identities and relationships between people and groups of people and contributes to their change (Fairclough, 1992; Fairclough and Wodak, 1997). According to Van Dijk (1997a,b), language users engaging in discourse accomplish social acts and participate in social interactions. The ideological loading of particular ways of using language and the relations of power that underlie them, however, are often unclear to people, particularly when the discourse is on scientific results whose understanding and comparative evaluation demands a high level of competence and a significant amount of time. The CDA, therefore, aims at making more visible these opaque aspects of discourse.

The arguments referring to science reflect a ‘vision of the world’ specific to each actor. To frame these constructivist aspects (i.e., ‘social construction’ of scientific knowledge), our method also includes the tradition of the ‘argumentative discourse analysis’ (ADA) and the ‘analysis of controversies’. We applied the concept of social construction by identifying the social mechanisms (e.g., strategic selection of data and experts) by which stakeholders ‘transform’ the existing scientific evidence with the purpose of defending their own stakes.

ADA (Majone, 1989; Fischer and Forester, 1993; Hajer, 1995) combines the analysis of the discursive production of reality with the analysis of the sociopolitical practices from which social constructs emerge and in which the actors are engaged. The meaning of the scientific evidence in a given context is analyzed within the context of the particular social practices in which the discourse is produced.

The ‘analysis of controversies’ focuses on disputes, which highlight the social contradictions inherent in many decisions about science and technology, in order to describe the special interests, vital concerns, and hidden assumptions of various actors (Nelkin, 1992).

The present discourse analysis was based on about 400 written texts. These texts were selected with regard to the criterion of their purpose, i.e., the communication of one actor's position on the statement/action of another actor. They included speeches, press releases, documents of position made available through Internet sites (e.g., Apiservices – beekeepers' website, the website of the Ministry of Agriculture, the website of the State Council, the website of Bayer CropScience),

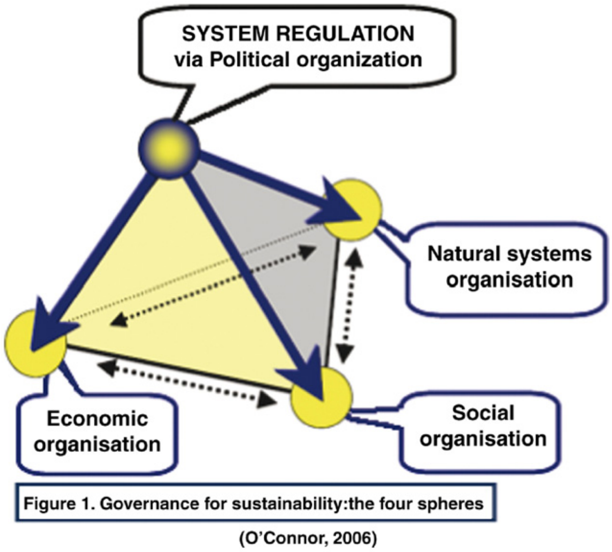

Fig. 1. Governance for sustainability: the four spheres.

decisions of the State Council, the Commission for Toxic Products, and the Ministry of Agriculture, meeting records, and newspaper articles. Because much of the conflict took place using communication tools largely available to the public, the Internet websites provided many documents. Unpublished documents were obtained directly from the respective actors.

The analysis in Section 3 was restricted to those documents that made reference to scientific results (58 texts). The parts of text that referred to the same scientific issue (e.g., the effect dose) were extracted and put into a comparative table (not shown but obtainable from the authors), whose columns were the actors of the debate and whose rows were the affirmation (citation) and the context in which the citation was produced. These citations were ordered chronologically. In this way, we could identify patterns in the discourses (that is, the 'scientific objects' evoked in Section 3) and points of divergence between the different actors with regard to the manner in which they addressed the 'scientific objects' in their discourses.

To compare the scientific evidence existent at a given time, we mainly used the report of the SCT. It presents an inventory of all scientific sources, methods, and results relevant to the risks for honeybees of imidacloprid used in seed-dressing until 2003.

For the analysis of the socioeconomic stakes (Section 4), we also used both scientific and 'grey' literature (e.g., an OECD report, an audit report for the bee-keeping sector, and activity reports by Bayer).

The framework used for the analysis of the economic, social, and environmental stakes underlying the stakeholders' discourses (Section 4) is the so-called 'tetrahedron of the four spheres of sustainability' (O'Connor, 2006) (Fig. 1).

This tool, developed for the analysis of sustainability issues, highlights the interdependency between economic, social, and environmental dimensions. The economic sphere, often the principal focus of development policy discourses and indicators, depends for its viability on the vitality of the social and environmental spheres and, at the same time, affects them. Governance for sustainability, therefore, centers on the regulation of the economic sphere in relation to the two other spheres in order to assure the simultaneous respect for quality/performance goals pertaining to each of the three spheres and the respect of one sphere in relation to another (O'Connor, 2006). We focused on decision-making in a context of contradictory discourses. Our analysis was thus primarily looking at the political[4] arena, where arguments related to the environmental, social, and economic spheres are exchanged and sometimes collide. We studied the interfaces between the spheres of the tetrahedron: Policy–Economy (Section 4.1); Policy–Society (Section 4.2); Policy–Environment (Section 4.3); and the internal functioning of the Political sphere itself (Section 4.4). The analysis systematically looked at arguments

[4] In this case, the political arena is extended to the whole societal arena. The actors are not speaking (only) though the voices of their political representatives (as, for example, in Parliament), but directly influence the debate concerning the decision to be taken. Here, we can recognize one feature of the 'risk society' (Beck, 1992), which is the 'dissipation of the frontiers of politics'.

stemming from each of the three spheres (Economy, Society, and Environment) and investigated the roles and fates of these arguments in the decision-making dynamics within the political sphere. Note that non-human nature (Environmental sphere) does not voice demands directly in political forums. This sphere is represented by actors (e.g., Non-Governmental Organisations (NGOs)), who argue 'on behalf of the environment'.

The methodological starting point for Section 5 was that political decision-making on risks should be based on the full spectrum of the relevant knowledge available and should avoid biases in the knowledge base as much as possible (i.e., the highest quality knowledge available). The consequence of some discourses may be to boost the social debate, and even block decision-making, by creating a false image of contradictory arguments and no 'good science'. The conflict may be fuelled by the perception of some of the participants in the debate that the information transmitted by the discourses of others lacks quality, and consequently the latter's statements are unacceptable. In our analysis, we demonstrated the congruency (or lack of congruency) of the scientific evidence existing at a given time and the discourse of the actors involved referring to this scientific knowledge. We compared the scientific information communicated in the discourses of each actor with the scientific knowledge actually available at a given time to answer the question: was the scientific information communicated by this party the best scientific knowledge available at that time? We identified the reasons for the failures to express the best scientific knowledge in discourse. These reasons led to a lack of mutual acceptability, among the actors, of statements referring to scientific knowledge. They were expressed by the actors themselves in the debate. We organized these reasons into six criteria of quality (see Section 5).

These criteria are intended to counteract the biases in the knowledge base that emerge during stakeholders play and assure that each actor strives to communicate (and argue for one or another demand to decision-makers) on the basis of the highest quality knowledge available. Based on this argument, we argue that they represent criteria for the 'social quality' of the scientific knowledge.[5]

[5] In this respect, our methodological background relates to Habermas's concept of 'discourse ethics' (Habermas, 1984, 1987), which was further developed by Webler (1995) in his set of criteria for evaluating communicative action. We have not, however, discussed these criteria, because our approach is more focused in object, developing criteria of quality that are specific to the process of communication of the scientific knowledge.

3. How was scientific evidence of risk reflected in the stakeholders' discourses?

We clustered our findings into five groups: research hypothesis and the methods employed; honeybee exposure to imidacloprid; the lowest effect concentration; properties of imidacloprid: persistency in soils and presence in untreated crops; and impacts on non-target organisms and on the environment. They are discussed below.

3.1. Research hypothesis and methods employed

The regulatory procedure to assess the risk that sprayed ('classic') pesticides form for honeybees is based on acute toxicity (LD_{50}).[6] This value is then used to calculate a hazard quotient (HQ) (Rortais et al., 2005). The authorization dossier needed for marketing imidacloprid also contained only this indicator. This methodology for risk assessment, based on the idea of dose (of pesticide) per hectare, is not, however, appropriate in the case of systemic insecticides (GVA, 2006; Arnold, in AFSSA, 2002; SCT, 2003; Rortais et al., 2005; Halm et al., 2006), because it cannot account for many elements of toxicity that are highly important in the case of honeybees: chronic toxicity (Suchail et al., 2003), sublethal effects, and effects on the whole colony. If the risk assessment procedure commonly employed for pesticides is used, it is possible that new products will be falsely declared environmentally sound. The procedure of risk assessment chosen by the SCT for imidacloprid was based on the evaluation of the ratio PEC/PNEC (SCT, 2003). Because French authorization procedures did not utilize new research insights, this discrepancy between regulatory demands and scientific understanding still exists. Other hypotheses which are valid for sprayed pesticides but not for this new type of insecticide, have been equally questioned: the dose–effect relationship (Narbonne, in AFSSA, 2002; Suchail et al., 2003); the measure of honeybee intoxication by counting the numbers of dead honeybees in front of the hives (GVA, 2006); and the use of the employment dose to measure the effects of systemic insecticides (GVA, 2006).

3.2. Honeybee exposure to imidacloprid

[1994]

Bayer claimed that imidacloprid applied on seeds cannot be present in flowers, because it disappears

[6] Lethal Dose 50: the dose that causes the death of 50% of the exposed individuals.

before the treated plants flower (GVA, 2006; AFSSA, 2002). The consistent association between the use of Gaucho® in treating sunflowers and the appearance of intoxication symptoms during sunflower foraging, however, led *beekeepers* to suspect the presence of the substance in those parts of the plant utilized by honeybees. Based just on Bayer's dossier, the *Commission for Toxic Products* did not take into consideration all of the potential effects on honeybees before they granted marketing authorization.

[1995–1997]

All of *Bayer*'s studies concluded that Gaucho® used in sunflower seed-dressing is harmless for honeybees (GVA, 2006; Curé in AFSSA, 2002). However, the significant lack of quality in Bayer's studies was repeatedly demonstrated by *independent scientists*. *Beekeepers* and local/departmental state services also carried out field studies and showed the occurrence of symptoms in areas of extended monocultures seed-dressed with Gaucho® and the absence of other potential causes (Direction des Services Vétérinaires de la Vendée, le 29 septembre 1997; Chambre d'Agriculture de la Vendée, FDSEA de la Vendée, FDSEA des Deux Sèvres, 1999). The conclusion of the *Commission for Toxic Products* (11 December 1997), based on its first expertise report (Belzunces and Tasei, 1997), was ambiguous. Given the information available, the Commission said that it is not possible to conclude whether or not a causal link exists between the use of Gaucho® and the decline of honey yield found in certain regions.

[1998–1999]

The studies undertaken by *Bayer* during this period either could not detect imidacloprid or detected it, but could not quantify it (GVA, 2006; SCT, 2003). One exception was a laboratory study that quantified the substance in sunflowers treated with Gaucho® to be 3.3 ppb in pollen and 1.9 ppb in nectar (Stork, 1999, in GVA, 2006; SCT, 2003). According to Bayer, the results of field experiments would either prove or disprove the risk of an active substance, even if they did not confirm the results obtained in laboratory studies. The *State Council*, however, decided that the risk can be assessed if it is based on the results of both field experiments and laboratory studies. Reviews of Bayer's studies, conducted by *independent scientists* (honeybee specialists) showed major deficiencies, in particular a lack of scrupulosity: for example, inadequate experimental conditions (e.g., colony dimensions unrepresentative for the normal conditions of colony development, insufficient time allowed to observe foraging behavior); incorrect use of scientific terms (e.g., 'Chinese honeybee' is a term without scientific relevance); imprecise measurement methods; and deficient presentation of the results (e.g., lacking statistical tests, lack of replication, hazardous interpretation, laboratories are not named) (Arnold, in AFSSA, 2002; SCT, 2003). The first independent research program (INRA, CNRS and AFSSA, 1998) identified the presence of imidacloprid in plants during flowering and abnormal honeybee behavior at both treated and control sites. This last finding led the researchers to address the problem of imidacloprid's persistence in soils and its presence in untreated crops cultivated in soils previously used for treated crops (Bonmatin et al., 2000). The analytical techniques available at that time allowed the detection of imidacloprid, but not its quantification below 10 ppb. Throughout this period, *beekeepers* summarized the results of the studies conducted by Bayer, the Ministry of Agriculture, and independent research institutes and compared them with their own field observations. The beekeepers' objective was to make the results public in order to show the congruity of their own observations and the scientific results and to mobilize the civil society for support. The conclusion of the *Commission for Toxic Products* was ambiguous: the data examined did not allow the conclusion of an unquestionable effect of imidacloprid or its metabolites on honeybees or honey yield, nor did it totally exclude the effect of imidacloprid and its metabolites. Consequently, the Commission reported that additional studies are necessary (16 December 1998).

[2000–2004]

Bayer received precise results during this period (3.3 ppb in sunflower pollen and 1.9 ppb in nectar (Stork, 1999, in SCT, 2003)). Nevertheless, the company reported "*an exposure between 0 and 5 ppb*" (Curé, in AFSSA, 2002, p. 32). The value of 5 ppb is the quantification limit declared by Bayer for the dosage of imidacloprid in Gaucho®-treated sunflowers and maize. We, however, showed that Bayer had already obtained lower measurements (using radioactivity-based methods). In view of the relevancy of the existing knowledge, this 'semantic slip' blurs the message by strategically selecting among the measurements available. The underlying effect of this linguistic construct is to suggest imprecision: "*in certain cases, the analysis revealed the presence of a residue, but only below the* *quantification limit*" (Curé, in AFSSA, 2002, p. 32). Moreover, *independent research* had already reported (two years before) available quantification and detection limits well below those used by Bayer: quantification limit at 1 ppb (pollen and nectar) and a detection limit at 0.3 ppb for pollen (Bonmatin, 2001, in SCT, 2003) and 0.8 for nectar (Lagarde, 2000, in SCT, 2003). Imidacloprid was measured in the pollen of sunflowers and maize in concentrations between 2 and 4 ppb. *Beekeepers* systematically present these results in order to assure transparency and to gain public credibility. In 2001, they summarized in detail the existing studies (GVA, 2006) and concluded: "*in semi-controlled and controlled conditions, harmful effects are observed for concentrations strictly of the same magnitude as those which the honeybee inevitably encounters in the field during sunflower and maize flowering*" (21 January 2001, www.beekeeping.com). Among the available results, the *Commission for Toxic Products* selected a measurement of 2–3 ppb for the imidacloprid present in the pollen and nectar of Gaucho®-treated sunflowers. The argument that the Minister of Agriculture used for not banning the use of Gaucho® in maize seed-dressing (February 2001), however, was that honeybees do not consume maize pollen. The scientific error contained in this conclusion was reconsidered the next year (September 2002) by the State Council, which consequently advised the Minister to reconsider his decision. The values validated by the SCT were 3.3 ppb and 3.5 ppb in the pollen of Gaucho®-treated sunflowers and maize, respectively, and 1.9 ppb in the nectar of Gaucho®-treated sunflowers. Recently published results of a survey initiated in French apiaries to monitor the weakness of honeybee colonies showed that imidacloprid had become a common contaminant of the environment (the most frequently found residue was imidacloprid: in 49.4% of the samples) (Chauzat et al., 2006).

3.3. The lowest effect concentration

[1997–2002]

In 1997, *Bayer* declared that the first biological effects appear at 5000 ppb. Two years later, however, the LOEC (lowest observed effect concentration) value identified by a Bayer study was well below this value: 0.5–7 ng/honeybee (20 ppb) (Kirchner, 1999, in SCT, 2003). In 2000, sublethal effects were identified at very low doses (0.075–0.21 ng/honeybee, i.e., 3 ppb in a solution containing imidacloprid) by scientists working in *independent research* (Colin and Bonmatin, 2000, in SCT, 2003). These researchers concluded that the environmental soundness of imidacloprid "*is necessarily arguable*" (Bonmatin et al., 2000). From the available results, the *Commission for Toxic Products* selected 12 ppb as the lowest effect dose. *Beekeepers* have continued to present the results of independent research, emphasizing that doses as low as 3 ppb and 6 ppb affect honeybees (GVA, 2006).

[2002–2003]

Bayer claimed that the lowest effect dose is 20 ppb, but failed to mention that this result was obtained during an open-field study. Thus, the company stated that for the studies "*made on complete colonies in the open field… the first negative effects are not observed at 20 ppb. The first observed effect of imidacloprid is a refusal to feed from the contaminated source and thus the end of foraging*" (Curé, in AFSSA, 2002, p. 32). This claim inadequately reflects the results of the respective study (Kirchner, 1999, 2000, in SCT, 2003), in which the effects observed in the open field, and caused by 0.5–1.4 ng/honeybee (20 ppb), were not the refusal of feeding, but a decrease in the frequency of wagging dances (which is correlated to recruitment in the colony for a food source), a change in dance precision (concerning the direction), and the occurrence of trembling dances (which is an inhibiting behavior for foraging recruitment and often observed in intoxicated bees) (Kirchner, 1999, 2000, in SCT, 2003). This contradiction can be attributed either to Bayer's inability to interpret the results of the study or to strategic behavior on the part of Bayer. One of Bayer's main arguments for claiming the absence of effects of Gaucho® on honeybees was that field experiments do not confirm the symptoms observed by the beekeepers (Curé, in AFSSA, 2002; Tossen, in Parlement Wallon, 2004; Bayer Cropscience, 2006). The studies available during this period and *validated later by the SCT* recorded measurements well below those reported by Bayer, for both laboratory and tunnel or flight-room studies. A number of studies reported the following sublethal effects for imidacloprid: 0.075–0.21 ng/honeybee (3 ppb); 0.15–0.42 ng/honeybee (6 ppb); 0.25–0.7 ng/honeybee (10 ppb), and 0.31–0.87 ng/honeybee (12.5 ppb) (Colin, 1998; Colin and Bonmatin, 2000; Decourtye and Pham Délegue, 1998; Pham Délegue and Decourtye, 2000; in SCT, 2003). Based on the results produced by independent research, the *beekeepers* supplied arguments in support of their demand to ban the use of Gaucho®. Three of the available results for the effect dose of imidacloprid were validated in 2002 by the *Commission for Toxic Products* and ranged from 0.15 ng/honeybee (laboratory) to 7 ng/honeybee (open field).

3.4. Properties of imidacloprid: persistency in soils and presence in untreated crops

[1994]

Even though its half-life greatly exceeded European norms, Gaucho® was authorized for marketing.

[1997]

The *Commission for Toxic Products* confirmed the half-life of imidacloprid to be 2–3 times longer than the one accepted by European norms (Belzunces and Tasei, 1997). The French jurisprudence,[7] however, stated that, despite its half-life in the soil, a substance may be authorized if it is "*scientifically proven that, in the relevant field conditions, the accumulation in the soil is insufficient to cause an unacceptable level of residues in the following crops, and that there is neither unacceptable phytotoxic effect for the following crops, nor unacceptable effect on the non-target species*." In this case, the benefit of the doubt with regard to the lack of precision of what 'acceptability' means was to Bayer's advantage, not that of the environment.

[1998–2001]

Results obtained in 2000 showed the persistency of imidacloprid in soils and its presence in untreated crops growing on soils where a crop treated with Gaucho® had been previously grown (SCT, 2003). Assessment of the available documentation led the *Coordination of French Beekeepers*[8] (GVA, 2006) to conclude that the substance is found in amounts of ~10 ppb in soils (the year of treatment). Subsequently untreated crops absorbed the chemical in concentrations comparable to those present in the treated crops.

[2003]

The scientific evidence validated by the SCT confirmed the presence of imidacloprid in soils that were used for crops seed-dressed with Gaucho®. The average levels found were 10.25 ppb the year of treatment and 4.4 ppb the year following the Gaucho®-treated crop (SCT, 2003).

[7] Arrêté du Ministre de l'Agriculture de 6 septembre 1994.

[8] The Coordination of French Beekeepers (Coordination des Apiculteurs de France) represented the interests of all three national beekeeping syndicates.

3.5. Impacts on non-target organisms and on the environment

Bayer judged the risks that imidacloprid forms for the environment to be either nonexistent or 'acceptable' (Bayer, 2001). *Available scientific knowledge*, however, indicated negative effects on other insects (including pollinators), birds, and aquatic organisms. Both *researchers* and *beekeepers* insist that the honeybee, in this case, represents a bioindicator for the state of the environment. The Minister of Ecology also held imidacloprid responsible for the bird intoxication observed in France after 1995 (GVA, 2006). Imidacloprid authorization data in several countries has shown different toxicity levels for birds, pollinating insects (particularly honeybees), fish and other aquatic organisms, and mammals (pesticides authorization registers for Portugal, Belgium, Spain, Canada, and the United States, websites visited in January 2006).

4. Social, economic, environmental, and institutional stakes underlying stakeholders discourses

4.1. The interface between policy and economy. Stakes for the regulation of the economy

The *chemical industry* has increased its global sales tenfold since 1970, and the OECD scenarios for the year 2020 anticipate a continuation of this trend. Presently, it is the third-most important economic sector in the world. The European chemical industry holds the first place in this sector, followed by that of the USA. Last years' strategy of the chemical industry was to transfer the production of basic substances to non-OECD countries and focus, in Europe, on specialty products (agrochemistry, pharmacy, biotechnologies, etc.) (OECD, 2001). The winners on the European market will, therefore, be the ones having a high innovative capacity. New active substances have to be marketed as quickly as possible, particularly in the field of agrochemistry. Risk assessment of 'new substances' before marketing, however, has classified about 70% of them as dangerous (Donkers, 2005). The French agrochemical industry has an important position both as the producer and as the seller of pesticides, because France is the number one European consumer of these substances.

The strategic behavior of the agrochemical industry is determined both by these economic factors and by the regulatory environment. The Directive 91/414/EEC stipulated a reassessment of the active substances contained in plant-protection products already on the market in the EU at the starting date of the directive. The industry responded to this directive by developing a new generation of plant-protection products (neonicotinoids, including imidacloprid and phenylpyrazols). Since the risk-assessment procedure proposed by the directive is inappropriate for these new insecticides, these substances may receive market authorization despite their potential environmental risks. This, therefore, may provide the respective companies with the competitive advantage of fast market introduction (see Section 3).

Another aspect of the industrial strategy relates to the alliances between big companies in order to control specific market shares. An important part of global production is assured by the number of multinationals inside the chemical industry and the tendency is still towards mergers (OECD, 2001). Size has become essential for profitability, i.e., to absorb growing research and development costs. Total average expenditures for the development of a new product are about 50 million US dollars (Assouline and Joly, 2001). The benefits with regard to systemic insecticides largely justify the investment. One example is Régent TS® (active substance: fipronil): sales of this systemic insecticide earned 122 million euros for Aventis CropScience in 1998 alone (Hicks, 2000). Similarly, insecticides containing imidacloprid are among those sold the most globally. Financial investments are also accompanied by investments in partnerships with seed producers and distribution networks.

Through the merger of Rhône-Poulenc with Hoechst, the newborn Aventis became number one on the global insecticide market (with a share of 17%) and the European leader in plant-protection products (24% of the market) (Hicks, 2000). Its agrochemical division was sold to Bayer in 2002. The financial importance of imidacloprid for Bayer is immense: in 1998, sales of the four pesticides containing imidacloprid reached 800 million DM. In 2005, France was the number one European market for Bayer CropScience Monde and number three globally (www.bayer.fr).

4.1.1. Farmers and seeders

In France, the maize seed branch generates an annual turnover of about 650 million euros. This makes maize the number one crop in the country and France the European leader of maize production and the primary global exporter (Maïz'Europ', 2006). The agricultural sector has since been divided by the two sides of the debate: syndicates representing intensive agriculture have joined forces, with regard to interests and arguments, with agrochemical companies, while the syndicate *La Confédération Paysanne* supports the honeybee's role as bioindicator, the high economic stake represented by pollination by bees, and the need of a partnership between farmers and beekeepers.

4.1.2. Beekeeping sector

In 1994, the French *beekeeping sector* consisted of 1 370 220 beehives and 84 800 beekeepers. In 2004, there were 1 360 973 beehives, but 15 200 fewer beekeepers (GEM-ONIFLHOR, 2005). Because of the decrease in the average yield/hive and the increase in colony mortality during this period, beekeepers had to increase the number of hives per exploitation in order to compensate for their losses. The apparent stability of the number of hives between 1994 and 2004 does not correctly portray this replacement of lost hives. Many small producers (i.e., those owning less than 70 beehives) were unable to cover their losses and had to abandon beekeeping.

Until 1994, a stable productivity had allowed French beekeepers to face the competition with imported honey. Severe losses in the yield of sunflower honey started in 1995 (Coopérative France Miel, in GVA, 2006). The statistics indicated a strongly decreasing tendency (−46%) in sunflower honey yield between 1992 and 1999 for the French regions Deux-Sèvres and Charentes et Poitou (GVA, 2006). In addition, an audit of the beekeeping sector showed a decrease of 3000–4000 tons of honey on the national level between 1997 and 2004 (GEM-ONIFLHOR, 2005). Added to these losses, i.e., losses due to the replacement of hives and the decrease in honey production, were the expenses made for research (beekeepers were contributing their financial resources from the European support to beekeeping, which are normally meant to develop the sector, to research programs assessing the risk of Gaucho®). Additional expenses, including attorney fees, were incurred when the debate went to court.

4.2. The interface between policy and society. Stakes to assure environmental justice

The press often highlighted the unequal power of the two 'discourse coalitions' involved in the debate to influence decision-making: one side comprised the French agricultural sector, the number one chemical industry in Europe, the chief branch of European seed-producers, and the goodwill of the Ministry of Agriculture, while the other was made up of honeybees, beekeepers, researchers, and the civil society. The response strategy of the beekeeping sector was characterized by cohesion inside the group (among the different syndicates) and extreme assiduity. The sector's excellent communication strategy, focused on logic and scientific arguments, favored the visibility of the stakes involved. Moreover, the sector received support from the civil society, not only because the financial status of the beekeepers has been severely affected, but also because their stakes were human, relating to dignity and social recognition. They affirmed the right to reject decisions that concerned them but in which they were not involved and refused to allow priority to be given in decision-making to the criterion 'economic weight' to the disadvantage of 'equity'.

4.3. The interface between policy and environment. Stakes for the implementation of environmental policies

In a letter published in Le Point on November 21, 2003, Yves Schenfeigel, head of the Bureau for the Regulation of Pesticide Products (Ministry of Agriculture), revealed the failure of the administration to assure the efficiency of the authorization process: "*three public servants for dealing with 20 000 demands of authorization per year, a joint management of the risk assessment with industrials, lack of transparency in the procedures… in the field of risk assessment, the domain of pesticide residues in aliments is insufficiently covered.*" In consequence, "*it is impossible for the bureau to accomplish its missions*". This fact may explain why the authorizing body failed to adequately evaluate the indices of the potential risk of imidacloprid contained in the authorization dossier (the LD_{50} was among the lowest known, the half-life in soils was very high). Moreover, the Ministry of Agriculture was in a conflict-of-interest situation because it was simultaneously responsible for two sectors that often have contradictory demands (beekeeping and agriculture). The French Committee of Prevention and Precaution confirmed this in 2002 by showing the need for changing the patterns of managing pesticides' risks to health and the environment (Comité de prévention et de la Précaution, 2002).

4.4. The internal functioning of the political sphere. Stakes with regard to the ability of the political system to perform the arbitrage between social, economic, and environmental spheres

During the Gaucho® debate, the attitude of the French governmental departments oscillated between opacity (refusal to release public documents), hesitation (contradictory or ambiguous statements), and open negation of the statements of researchers and beekeepers. This enhanced the mistrust of the beekeepers and the civil society, who then accused the government of a technocratic approach to expertise, incompetence, and favoritism towards the agrochemical companies (AFSSA, 2002; GVA, 2006). The concerns of these two groups were justified in January 2000: despite the manifold results issuing from independent research that established the harmful character of imidacloprid for honeybees, the Minister of Agriculture renewed Gaucho®'s authorization for 10 years. Moreover, this occurred during the period when the annulment procedure of this authorization was before the State Council.

5. Discussion

The present case study showed that, even when the scientific evidence of the risks was strong, stakeholders still attempted to influence the interpretation of the evidence, and as a consequence political decision-making, in their best interest. This confirms the constructivist view that science is colored by the context in which it is produced.

The second research question of this study comprised methodological aspects of assessing the quality of information. Social aspects of uncertainty play a crucial role in decision-making. However, within the new field of knowledge quality assessment, methods for the evaluation of social uncertainty are still in an early phase of development (Van der Sluijs, 2006). The results of the present study could be a starting point for further research in this field, because they allowed us to formalize six criteria for the quality of information communicated in an argumentative policy process. These criteria are discussed below.

5.1. Reliability of the information – it must be based on all available scientific knowledge

When uncertainty is at the heart of a social debate and knowledge is being sought to support that debate, it is vital that all statements weigh the most recent information found and include findings from scientific sources other than the actor's own expertise. Arguing from an epistemological point of view stresses the key importance of what Dunn (2001) called 'context validation', i.e., the information used in decision-making should cover the complete set of relevant knowledge present in a particular policy context. In other words, the scope of the knowledge considered must be broadened in order to minimize the possibility that important aspects are overlooked (see Section 3).

In the present case, many of the pesticide producer's conclusions were the result of a stake-driven selection of the results made available by experts, without scientific criteria for validating the choice made. For the non-expert audience (the general public and policy-makers), these arguments may seem as valid as any issuing from scientific work. For the independent researchers, however, the scientific quality of several of Bayer's conclusions was highly arguable. The selective use of knowledge can be legitimate only as long as it is clear what information has been omitted and why, following a process of review and argued selection, that information is considered less relevant to the case.

5.2. Robustness of the information – it must take into account criticism

The 'experts' contradictions', which were so often evoked during the years of the Gaucho® debate, were due partly to the lack of standardized procedures (SCT, 2003) and partly to the failures of communication between the scientific community and the regulatory bodies. About 20 years before the Gaucho® debate, researchers had already started reporting that LD_{50} alone was not sufficient to study the risk that pesticides form for honeybees (AFSSA, 2002). These warnings were ignored by the French government. Similar cases included asbestos and mad cow disease: decision-makers also ignored the signals coming from scientists (EEA, 2001).

5.3. Use of the information produced by other stakeholders

The use of information produced by all stakeholders in the construction and assessment of the knowledge used for decision-making is vital in the management of social processes associated with environmental risks. Stakeholders can contribute to knowledge production in a number of ways: for example, by contributing knowledge on local conditions (e.g., the consistent association between sunflower foraging and symptoms) which may help determine which data are strong and relevant and which symptoms require further investigation (e.g., symptoms observed by beekeepers caused independent research to address specific target points of honeybee intoxication); by providing personal observations which may lead to new foci for empirical research addressing dimensions of the problem that were previously overlooked (e.g., exposure pathways via pollen and nectar were deemed impossible before beekeepers reported intoxication symptoms); by identifying new indicators that better match the problem as experienced by the stakeholders (e.g., beekeepers' observations led to including chronic sublethal effects in the assessment of risk); by thinking creatively about the mechanisms and hypotheses regarding the causal links between observed symptoms and possible causes (e.g., persistency in soils may explain the intoxication seen in bees foraging on untreated crops); and by scrutinizing and improving assumptions made in risk assessments so that they better match real-life conditions (e.g., Bayer's field studies ignored the fact that the diet of intoxicated honeybees was dictated by the several square kilometers of sunflower monoculture: i.e., it provided very little or no alternative diet. The honeybees in Bayer's field experiments had an alternative diet within their range of flight). By ignoring local beekeepers' knowledge and by repeatedly displaying an ambiguous attitude, the French Ministry of Agriculture repeated previous history of mismanaged environmental problems and contributed to the reinforcement of the conflict (De Marchi and Ravetz, 1999; EEA, 2001). By means of press releases and demonstrations, beekeepers systematically called for the application of the precautionary principle, because the wait for conclusive evidence on imidacloprid intoxication was severely affecting their livelihood.

5.4. Relevance of the arguments for issue under debate

The information communicated in an argumentative exchange must be relevant for the subject discussed. Some arguments, however, may try to displace the focus of the debate to completely different contexts or issues. For example, Bayer's conclusion regarding the absence of any risk of imidacloprid for honeybees made no reference to the relevance of the results obtained "*in different regions of the world*" (Bayer Cropscience, 2006), neither for large-scale sunflower and maize monocultures, nor for the specific situation in France.

5.5. Logical coherence of the discourse

The absence of internal contradictions in a discourse is vital for mutual trust among the stakeholders and is an essential factor for successful risk governance. For example, the findings of the SCT report, presented by Hervé Tossen to the Walloon Parliament, were as follows: "*The report of the Scientific and Technical Committee in France is the first of the three steps of the multifactor study and consists of a new review of the existing data. No new information concerning the use of Gaucho® on sunflowers and maize emerged from the Committee's report*". Compared to previous studies, however, this SCT report was the first to clearly demonstrate the risk imidacloprid, used in sunflower and maize seed-dressing, forms for honeybees. Hervé Tossen added: "*The researches and intensive studies realized by independent institutes and by Bayer confirm that Gaucho® is safe for honeybees. […] For maize, risk assessment was carried out and also concluded that there was no risk*" (Parlement Wallon, 2004, p. 13). It is clear that the results of the SCT report and Bayer's conclusions are contradictory. Once acknowledged, this type of language trick, often called a 'semantic slip' by the beekeepers during the debates, discredits the stakeholder who uses it and significantly reduces his/her opportunities for meaningful communication with the other stakeholders.

5.6. Legitimacy of the information source

The responsibility, impartiality, and independency of Bayer researchers have often been questioned by the independent researchers. In fact, they signaled procedural errors, incorrect reasoning, and a lack of understanding of honeybee biology. Moreover, the case of the systemic insecticide Gaucho® raised questions about the choice of experts working in expert committees, that represent a certain institution, with regard to their freedom, independence, and competence. In the case of imidacloprid authorization, for example, not one of the 50 members of the Committee for Toxic Products was a honeybee specialist and these specialists were under-represented in the Honeybee Working Group set up by the Committee. This definitely limited the ability of the Committee to judge on honeybee issues.

The study's third question addressed the lessons that can be drawn for the future governance of similar risks. Many of the EEA's twelve 'late' lessons (see Box 1) were ignored in the political process described above, including lesson 2 "*Provide adequate long-term environmental and health monitoring and research into early warnings*" (EEA, 2001, p. 168). From 1994 to 2004, the symptoms described by beekeepers were confirmed by different local/regional governmental services. These reports, however, were ad hoc and were never compiled at the national level for more than two years in a row. The Ministry of Agriculture repeatedly failed to run a workable monitoring network, which helped undermine the trust of the other actors and fuel the conflict.

As for EEA lessons 5 "*Ensure that real world conditions are adequately accounted for in regulatory appraisal*" and 8 "*Ensure the use of 'lay' and local knowledge, as well as relevant specialist expertise in the appraisal*" (EEA, 2001, p. 169), the declaration of one beekeeper is illustrative of how the process of expertise was experienced by the local actors: "*it is enough to come to the field. One hundred percent of those who came to the field were convinced. It is regrettable that we never saw those of the individuals who are making the decisions at this moment in their offices, or even some researchers who are members of certain important Committees and Commissions – them, we never saw them*" (Frank Alétru, in Elie and Garaud, 2003). Excluded from the process of gathering knowledge on the problem, but nevertheless suffering from the damaging effects of the delays in decision-making, the beekeepers often criticized the slowness of the analyses ('paralysis by analysis') and the diversion of research towards too 'complex' subjects. Our case study reinforces, therefore, EEA's lesson 12, which recommends that policy-makers "*avoid 'paralysis by analysis' by acting to reduce potential harm when there are reasonable grounds for concern*" (EEA, 2001, p. 169).

The Ministry of Agriculture quickly initiated scientific studies after the Gaucho® problem became an issue of public debate. If it had been followed, the third EEA lesson ("*Identify and work to reduce 'blind spots' and gaps in scientific knowledge*") could have been fruitful. The ambiguity of the Ministry's public statements and the discrepancy between its conclusions and the results from independent research, however, raised important criticism on the purpose and the transparency of the official initiative. This result strengthens the focus on relevant specialist expertise noted in lesson 8. In other words, *assure the independency and competence for the given issue of the experts that you appoint as well as the complete transparency of the research process and the public availability of the results. Explain the reasons for your decisions regarding the choice and framing of the research programs and how they answer the demands of those concerned*.

The mad cow disease crisis, one of the EEA's fourteen case studies, caused an institutional restructuring in the UK. The British Ministry of Agriculture failed in both its missions, i.e., consumer protection and the defense of farmers' interests. As a consequence, the manner in which risks were assessed and managed in the UK changed and the Food Standards Agency was created. Insights from that case inspired lesson 10, which recommends the "*maintenance of the regulatory independence of interested parties while retaining an inclusive approach to information and opinion gathering*" (EEA, 2001, p. 169). In the present French case, the Ministry of Agriculture was also subject to a conflict of interests since it was responsible for both the interests of the agricultural sector and the management of risks issuing from that sector's activity. This resulted in the ambiguous attitude of the governmental bodies (see Section 4.4). It can be concluded, therefore, that *the responsibility for the management of risks associated with the activities of one sector should not be a task of a governmental body that is also responsible for the economic interests of that same sector.*

The present analysis also resulted in two more lessons on risk governance. First, it is a pitfall to assume that existing methods for dealing with the risks of existing technologies are also appropriate for dealing with new risks coming from new technologies. In the present case, the tools were not fit for the function for which they were used. Even though the nature of the risk posed by systemic pesticides was radically different from the one associated with sprayed insecticides, the same assessment tools (LD_{50}, respectively HQ) were used. Consequently, their use delayed the recognition of the risks imidacloprid formed for honeybees. This lesson can be composed as follows: *When dealing with the risks of new technologies, verify whether the methods available for their assessment are appropriate.*

Second, it is a pitfall to underestimate the problems related to the means and efforts needed to implement policies. The case of Gaucho® revealed the failure of the French administration in dealing with the demands necessary for the authorization of new pesticides. In the eyes of the general public, this failure seriously undermined the Ministry of Agriculture's credibility with regard to its real efforts to assure the coherence of the authorization process and thus protect human health and the environment. Policy-makers, therefore, need to provide *adequate human and financial resources in order to design efficient regulatory procedures for risk governance and thus reinforce their ability to effectively manage risks.*

In summary, our study built on the theoretical background of post-normal science and the sociology of scientific knowledge. In the field of KQA tool development and precautionary risk governance, we introduced a new conceptual distinction between scientific uncertainty and the social construction of uncertainty. We also developed six knowledge quality criteria that can be used in the assessment of information communicated in an argumentative public process. In the field of discourse analysis, our approach confirmed the relevance of using the 'tetrahedron of governance for sustainability' as an innovative method for the systematic analysis of the stakes that form the context of discourses on risks. The case study confirmed the assumptions of the sociology of scientific knowledge regarding the key role of context in knowledge production and use. In the field of environmental sciences, the study described an innovative socioeconomic approach to a class of new pesticides (systemic insecticides) and to the emergence of new risks. Finally, in the field of precautionary risk governance, we were able to add two additional lessons to the twelve already developed by the EEA.

6. Conclusions

Based on the French controversy over the risk that the systemic insecticide Gaucho® forms for honeybees, this paper explored the phenomenon of the social construction of uncertainty and its role in discourses on risk governance. Our case analysis clearly demonstrated that the social, economic, and institutional stakes of the actors involved in the controversy strongly shaped the discursive strategies used to cope with uncertainties. Typical phenomena observed in this risk controversy were: the strategic and selective use of risk information; the use of outdated and disproved methods (not meeting state-of-the-art detection limits), and of inappropriate regulatory approaches (dose per hectare acute toxicity is inadequate for systemic insecticides); the systematic omission of local knowledge, denial of its relevance, and discrediting it as 'unscientific' (beekeepers' local knowledge of their honeybees' symptoms); the blurring of the debate by presenting data irrelevant to the case; the use of language tricks and semantic slips, and suggesting (undue) imprecision; the persistent exclusion of key expertise and competence in expert committees that advise on market authorization (very low representativeness of honeybee experts in the Committee for Toxic Products, including the Honeybee group).

To remedy these major flaws in discourse that hamper effective and timely precautionary risk governance and timely recognition of and response to early warnings, we proposed six knowledge quality criteria that can assist in the assessment of the information communicated in an argumentative public process. They are as follows: reliability of the information – it must be based on all available scientific knowledge; robustness of the information – it must take into account criticism; use of the information produced by other stakeholders; relevancy of the arguments for issue under debate; logical coherence of the discourse; and legitimacy of the information source.

We compared our findings with the twelve lessons of the EEA (*Late lessons from early warnings*) and concluded that many of these 'late' EEA lessons can also be drawn from the present case. Further, the imidacloprid/honeybee case allowed us to draft two additional lessons:

- Update risk assessment methods to fit new risks
- Assure adequate institutional capacity for efficient administrative procedures of risk governance

All of these lessons should be applied to future policies in order to minimize the repetition of past mistakes.

Finally, conclusions can be drawn about the capacity of contemporary democracies to answer societal demands. Principles of democracy, social equity, ecological responsibility – all of these challenge the liberal criteria for decision-making: financial profits – but for whom? profitability of agriculture and industry – at the cost of the profitability of beekeeping? and at what social and environmental price? The case of Gaucho® versus honeybees is symbolic for the actual crisis (sign of a transformation?) frequently seen in representative democracies.

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