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The Co-Production of Scientific Advice and Decision Making under Uncertainty: Lessons from the 2009 L'Aquila Earthquake, Italy

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Abstract – On 22 October 2012, seven members of the Italian Major Risk Commission were found guilty the injuries of 4 and manslaughter of 29 people in relation to the 2009 earthquake that hit L'Aquila, a town in Central Italy. These members were sentenced to six years in prison for failing to meet their obligations to adequately analyse seismic risk and provide clear, correct and complete information, which might have saved many lives. The case has not yet been concluded. Thus far, the debate has mainly focused on the scientific, legal and communicative aspects of the verdict, while the institutional dimension, including the co-production of scientific advice and decision making, has received less attention. Co-production processes shape how scientific advice is used to make real world decisions and how different priorities, tasks, purposes and organizational cultures of scientists and practitioners can influence the decision making process. We argue that understanding the event and the legal aftermath requires a knowledge of the deep epistemic uncertainty intrinsic to the nature of scientific advice as well as the responsibility overlaps of scientists-turned-decision-makers. Another relevant institutional aspect is the concern of the national and local authorities that the population would over-react to anything other than a reassuring message. We discuss the consequences of this framing of the emergency management problem in terms of public control rather than public safety. We argue that an effective warning communication should inform people about the precautionary actions to undertake as well as the risks, benefits, and costs of their decisions, thereby allowing them to make sound and responsible choices.

Keywords – *epistemic uncertainty, science policy co-production, emergency communication, communication paradoxes*

1. Introduction

Providing scientific advice to decision makers has never been easy, and it is particularly difficult when the facts are uncertain and the stakes are high, as it is in issuing a warning for a natural disaster (Funtowicz and Ravetz 2008). One aspect of the communication difficulty is that scientists work in a world of uncertainties and probabilities, while practitioners and decision makers often prefer straightforward answers and clear suggestions about what to do, especially when facing a crisis (Cash et al. 2006; McNie 2007; Sarewitz and Pielke 2007). However, even if they have different priorities, tasks, objectives and even understandings of the problem, scientists and practitioners must cooperate in order for effective decision-making to take place, especially when scientific knowledge plays a determinative role. Given the differences in purposes and organizational cultures between the scientific and institutional communities, difficulties arise in conveying scientific uncertainties, in defining what is an acceptable level of risk and who has the responsibility to set the thresholds, and ultimately in making science useful for practitioners. Yet, notwithstanding these difficulties, decisions are co-produced through the interactions between these communities. Co-production processes shape how scientific advice is implemented on the ground. In its own turn, this advice can have relevant consequences for local residents, as was tragically demonstrated by the 2009

earthquake that hit the Italian town of L'Aquila.

The L'Aquila case shows how decisions become particularly difficult in cases of deep epistemic uncertainty and institutional overlap – i.e. when there are major gaps in the ability to understand phenomena and outcomes, coupled with overlapping roles, responsibilities and mandates in the decision making processes. The moment magnitude (Mm) 6.3 earthquake claimed more than 300 lives and injured more than 1600 people. It also represented a "worst case scenario" for scientific advisors, because it led to the conviction of seven members of the Italian Major Risk Commission for negligence in providing hazard-assessment advice before the earthquake. The allegation claimed that the scientists failed to fulfil their obligations to i) provide clear, correct and complete information that might have saved many people lives and, ii) adequately analyse seismic risk (as reported in the verdict n.380/2012). Following their conviction, the members were sentenced to six years in prison and fined several million euros. At the time of this writing (August 2013), the accused scientists are appealing the verdict and legal experts anticipate that the final resolution of the case may be years away.

This case provides a sobering opportunity for reflection for those who deal with disasters and disaster research, for several reasons. As we will describe in the following sections, the verdict caused heated reactions. So far, the debate has focused on the scientific, legal and communicative aspects of the verdict, while the institutional aspects have received less attention. Here, we focus on the institutional facets of the phenomenon and more precisely on the role of scientists as advisors in the decision-making process as well as the multiple institutional and communicative issues that influence how science advice is given and received. In order to comment on these issues, we start by providing a description of what happened in L'Aquila before and after the 2009 earthquake.

2. The l'Aquila earthquake

2.1. The seismic swarm and the 6th April event

At 03:32 on 6 April 2009, a devastating Mm 6.3 earthquake struck the city of L'Aquila and its province, also named L'Aquila, in Central Italy. In addition to claiming more than 300 lives and injuring more than 1600 people, the disaster destroyed some 20,000 buildings and left 66,000 people temporarily displaced with an estimated damage of some 16 billion USD (Ozerdem and Rufini 2013; De Marchi 2013 b). The main shock had been preceded by a seismic swarm with hundreds of modest phenomena up to a magnitude Mw 4.0 on 30 March 2009. This swarm originated approximately half a year earlier in October 2008. Given the long duration of the swarm, residents were understandably alarmed. In such a tense situation, the numerous unofficial warnings by a technician formerly working in a laboratory of the National Research Council captured significant media attention. On the basis of radon measurements that he had performed, he insisted that a major earthquake was soon going to occur. His unofficial warnings particularly outraged the head of the National Department Civil Protection (NDCP), who reported him to the authorities for diffusing alarming news. He also subsequently convened a meeting of the Major Risks Commission, which is a consultative body of the National Service for Civil Protection for "providing advice about forecast and prevention of the various risk hypotheses" (art. 9 l. 225/1992, last update l. 100/2012)[1].

The meeting of the Commission took place on 31 March in L'Aquila with the aim to "provide the citizens of Abruzzo with all the information available to the scientific community about the seismic activities of the previous weeks" (verdict n. 380/2012: III). As reported by the head of the NDCP, there was a "need to reassure the residents and to organize an event for the media (operazione mediatica)" (ibidem: 131). Already prior to the meeting, reassurance was provided to journalists and residents by a member of the Major Risk Commission stating that the seismic situation in L'Aquila was normal because of the continuous discharge of energy due to the seismic swarm (ibidem).

The need to reassure the population was also related to the fact that the situation had grown very tense and residents were confused by contradictory information. Moreover, given a history of such tragedies, such as a 1703 earthquake that killed more than 3,000, the recourse of action in the face of such swarms for the local population has been marked by high risk aversion with people frequently choosing to go outside to be safe in case of an earthquake.

During the meeting, it was reaffirmed that no scientifically sound method exists to predict earthquakes. The Commission came to the scientifically correct conclusion, that there is deep uncertainty and thus did not provide any specific line of action: "it is unlikely that an earthquake like the one in 1703 could occur in the short term, but the possibility cannot be totally excluded." (statement of a member of the Major Risk Commission). Today, science is still unable to predict earthquakes and seismic swarms are not robustly linked to large seismic events. Seismologists agree that it is not possible to identify *a priori* a seismic sequence that anticipates a large shock with respect to many other seismic sequences that do not end with a big earthquake. For example, according to Grandori et al. (2009), only 2% of swarm activity has been linked to large seismic events and there is no theory that links precursor signals conclusively to severe earthquakes. L'Aquila is such an example because the town had already experienced swarm episodes in earlier times, which did not lead to a large earthquake.

The meeting was followed by a press conference where no specific measures of protection were suggested while it was reiterated that no scientifically sound method exists to predict earthquakes.

[1]The Major Risk Commission activities are of a techno-scientific and advisory type and include providing guidance in connection with the forecast and prevention of the different risk situations. Among others, the Commission, which usually meets every two months, defines research needs for the Civil Protection, evaluates results and assesses risks

2.2. The verdict

Three and a half years after the event, a court case received major media attention. On 22 October 2012, seven members of the Italian Major Risk Commission were found guilty of manslaughter of 29 persons and injuries caused to 4 others. The 781-page verdict, made publicly available on 18 January 2013, is the result of a penal process which included 31 hearings from September 2011 to October 2012.

Some relatives of the victims claimed that because they believed the official information, their family members and themselves chose not to apply protective measures and did not leave their homes on the night of 6 April. As noted in the recently published verdict, the statements made during the press conference by the members of the Commission caused a "psychological reaction consisting in a double mechanism: i) collective removal of the seismic fear, ii) strong belief in the reassurance indications and assessments provided by the Commission, which has been favoured by its credibility and authority" (verdict n. 380/2012: 574). Moreover the judge focused on what he defined as contradictory information provided by the scientists which -the judge argues- reassured the population, likely also due to an "amplification effect" guaranteed by the media. As one example of contradictory information, the judge cited the excerpts of interviews by two members of the Commission: "Any earthquake forecast does not have scientific foundation" and "The scientific community tells us there is no danger because there is an ongoing discharge of energy" (ibidem: 375). These excerpts of interviews clearly illustrate the difficulties in conveying scientific uncertainty. So far, the existing discussion on L'Aquila earthquake has focused on the scientific, legal and communicative aspects of the verdict, such as earthquake forecasting, scientific proofs during a trial and uncertainty communication. In the next section, we will summarise the key points of this heated debate.

2.3. The reactions to the verdict

Earthquake forecasting represented one of the main topics discussed in relation to the L'Aquila case. Before the verdict, more than 5,000 scientists signed an open letter to the president of Italy, stating that the seven Italians face (unfair) criminal charges for failing to predict the earthquake. Pinpointing the time, location and strength of a future earthquake in the short term remains, according to a scientific consensus, technically impossible (Hall 2011). Seismologists from all over the world have expressed their support for the convicted colleagues, including support letters from more than thirty associations (for an overview see http://processoaquila.wordpress.com/international-support/; Nosengo 2010; Hall 2011; Aspinall 2011; Cartlidge 2012; Marzocchi 2012; Wyss 2013; Amato et al. 2013). The reactions have been focused on the lack of accepted scientific method for earthquake prediction, the ignorance of the general public (or even the jurists) about the concepts of probability or uncertainty and, more in general, on the scientific aspects of the verdict which has even been defined as a "lawsuit against science" (Amato et al. 2013; Marzocchi 2012).

The solidarity statements point out that it is not the fault of the scientists if the public and even the jurists are unable to understand what uncertainty in hazard and risk assessment really means and that better education should be provided. "If the jurists would have a correct perception of probability, this trial would have never started" (Gasparini and Leone 2012: I). Indeed "the accusation implicitly follows a logical fallacy: 'if scientists say that an event is unlikely, but this event actually happens, this means that the scientists are wrong'" (Marzocchi 2013:17). Many colleagues of the seven convicted add to this point by highlighting how the verdict wrongly assumes that there is a responsibility of scientists for the correctness of their assertions. The reactions from the legal community have also been heated, but they focused on different issues such as the concept of acceptable risk, the causal nexus between the experts statements and residents' behaviours, and more in general on the issue of scientific proofs during a trial, e.g. what proofs should be used and how to evaluate the quality of scientific evidence (Zalin and Butti 2013; Tallacchini 2013; Masera 2013).

Finally, what happened in L'Aquila has also been interpreted as a failure of science communication. For example, Ropeik (2012) maintains that "the trial was not about science, not about seismology, not about the ability or inability of scientists to predict earthquakes. These convictions were about poor risk communication, and more broadly, about the responsibility that scientists have as citizens to share their expertise in order to help people make informed and healthy choices." Beyond this we provide some additional reflections on the role and responsibility of scientists in the production of scientific advice for decision makers.

3. The co-production of scientific advice and decisions

Depending also on the (disciplinary) perspectives that are used to interpret what happened, many lessons can be derived from the L'Aquila case. So far, the institutional side of the decision process has received little attention. We argue that the presence of deep epistemic uncertainty intrinsic in the scientific advice coupled with unclear and mixed roles of the scientists-turned-decision-makers are fundamental to understanding the event and the legal aftermath. Two aspects are particularly relevant, one is related to responsibility overlaps and the other to the need of emergency managers to reassure the public and control overreactions of the residents.

3.1. Role and responsibility overlaps

After the meeting held on 31 March in L'Aquila, the members of the Italian Major Risk Commission simultaneously acted as advisors, public officials, and decision makers (without necessarily being aware of it). As reported in the minutes of the meeting, the aims were to: i) provide an objective evaluation of the seismic events, also in relation with what can be forecasted; and ii) discuss and pro-

vide advice about the warnings (Presidenza del Consiglio dei Ministri 2009). In other words, the scientists were requested to provide suggestions not only on scientific issues but also on decision making. Moreover, as reported in the verdict, "the Commission, due to a pre-established [by the head of the NDPC] communication strategy, was not addressing its advice to the Civil Protection Department, but directly to the population" (verdict n.380/2012: 175). To understand this point it is important to clarify that the Commission is a national consultative body representing the formal communication channel between the NDCP and the scientific community [2]. Its activities are of a techno-scientific and advisory type and in case of events of great intensity (defined as "Type C events", law 225/1992, law 401/2001, law 100/2012), the Commission is in charge of providing evaluations and assistance to the NDCP. On this basis, the last one (directly or through its local branches at the regional, provincial and municipal level) provides information to the population.

The legislation clearly distinguishes the role of the scientific advisor from decision makers, but the border between provision and communication of scientific information is easy to cross.

In this case, the scientists acted as advisors, public officials, and decision makers at the same time. It is clear that this overlap of roles influenced the entire communication process. In this way the scientists have been made co-responsible, if not entirely responsible, for the decision on how to communicate the risk to the population. Their role and related responsibility (of which most of them were not even aware of, see Boschi 2013) deflected the attention from the national and local decision making bodies for managing emergencies, and it also reflected the difficulties of those in power to actually make a decision on whether or not to evacuate an area. This is where the co-production of scientific advice and decision making became particularly difficult. In Italy, as in many other countries, the mayor is the ultimate responsible authority for issuing a warning after having consulted the provincial and regional authorities (l. 225/1992). The Italian legislative framework for warnings varies across the regions, but in general the laws do not provide specific tasks for different hazards. Indeed some hazards, like floods or storms, can be more easily associated to warnings, than for example earthquakes. In addition to false negative warnings as in the case of L'Aquila, false positives can have huge negative consequences and those in charge typically fear both situations (Woo 2011). For example, after the Sarno landslide in 1998 (which killed 137 residents), the mayor was sentenced to five years in prison and interdiction from public roles because he did not give an order to evacuate the town (Corriere del Mezzogiorno 2011). Another example is that one of the reasons why the New Orleans mayor was reluctant to order a city evacuation in 2005, when Hurricane Katrina hit the city, was the fear that the city government would be sued for disrupting local tourism (Woo 2011).

3.2. Public control and public safety

The relatives claimed that the behaviour of the victims was influenced by the reassuring information provided during the press conference by the members of the Major Risk Commission. As repeated several times in the verdict, the aim of the Commission meeting was actually to reassure local residents and to spread the message through the mass media (court verdict n.380/2012: 169). The meeting was followed by a press conference where no specific measures of protection were suggested to the citizens. However, it was also reaffirmed that no scientifically sound method exists to predict earthquakes. Reassurances were provided to journalists and residents that the seismic situation in L'Aquila was normal and "favourable because of the continuous discharge of energy due to the seismic swarm" (court verdict: III).

Finding ways of reducing residents' psychological stress after months of minor tremors and avoiding panic was a major concern for practitioners and emergency managers. As reported in the minutes of the meeting of the Major Risk Commission: "The problem is worsened because the population is worried and alarmed from uncontrolled voices which cause panic. We have to understand what is going on from a scientific point of view and provide reliable/certain information" (Presidenza del Consiglio dei Ministri 2009: 2). In other words, national and local authorities seemed to be motivated by a concern that people would over-react to anything other than a calming message and the risk management problem was therefore framed in terms of public control rather than public safety (De Marchi 2013 a).

Such behaviour is not new and has been reported in several other cases and studies in the field of psychology, sociology of disasters and risk communication (e.g. Quarantelli and Dynes 1972; Otway and Wynne 1989). Research results have shown how fear can be an effective mechanism in the event of an impending and unpredictable danger. And indeed fear is a mechanism that keeps animals (including humans) alert in dangerous situations, as opposed to panic, which triggers life threatening behaviour. Unfortunately, avoiding panic is such a major concern for public authorities that they often fail to make the appropriate distinctions between fear and panic, focusing their attention on the possibility of panic and assuming that residents would adopt life-threatening rather than life-saving behaviours.

In risk communication research, this concept has already been defined as the information targeting paradox (Otway and Wynne 1989). This paradox concerns the assumption of the public authorities that the dissemination of emergency information must be restricted to avoid public overreactions and panic. The same authors also defined another paradox, which can be relevant for the case of L'Aquila, i.e. the information cultures paradox, which arises from the awareness that each organization reflects its own information culture need. Science and decision-making are separate domains with very different forms of

[2] This definition is reported in the official website of the Italian Civil Protection Agency.

legitimization, and therefore have different ways of producing and defining uncertainty, usable knowledge and information, etc. (Fischoff 1995, 2013; McNie 2007). In this case the main objective of scientists and researchers was to deal with uncertainties in hazard and risk assessment. The main objective of practitioners was instead to avoid liability in case of damages or, even worst, losses in human life.

4. Discussion

The case of L'Aquila is particularly tragic and complex as a risk that could not be robustly predicted turned into an actual disaster. There are other disasters that can be predicted and where early warning is effective. Yet uncertainty is a key issue to reckon with as well. As described in the previous sections, a key problem was the deep epistemic uncertainty and the fact that it is still not possible to provide clear information on the role of seismic swarms as earthquake precursors. Yet, an important question remains: How could available information reassure the population? Or, more in general: How could any kind of information reassure the population, if earthquakes cannot be predicted? (De Marchi 2013 b) How can this information be communicated to citizens while taking into consideration two contradictory goals, i.e. to avoid messages leading to overreactions by population and to provide information under conditions of epistemic uncertainty?

Beside the lessons that can be learned from research in sociology and risk communication (see section 3.2), there is also a need to better understand not only the kind of information that scientists can provide, but also the purpose of this information and how it fits in the decision-making chain. The quality of a decision cannot be evaluated separately from the process, which leads to it and requires transparency and accountability.

To summarise, we argue that to better understand the co-production of scientific advice and decision-making in the case of deep uncertainty, the role and mandate of scientific advisors needs to be carefully evaluated and explicitly defined. This raises a number of questions, such as who should actually be responsible for decisions about the warning, how this responsibility should be shared with local population, what is the purpose of the scientific advice provided by experts, who are the recipients, and to what extent are they responsible for their own actions and decisions. An effective warning should inform people about potential protection action to undertake and about the risks, benefits, and costs of their decisions, thereby allowing them to make sound and responsible choices (Fischhoff 2013).

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