Science & Technology Studies

3/2018

Science & Technology Studies

ISSN 2243-4690

Subscriptions

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The subscription rates (2018) for access to the electronic journal is 40 euros for individual subscribers and 100 euros for institutional subscribers.

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Science & Technology Studies

Volume 31, Issue 3, 2018

Editorial

Articles

Book review

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Editorial

Salla Sariola

You are holding the 30th anniversary issue of Science & Technology Studies.

With this editorial the journal wishes to thank the readers, authors, reviewers, book reviewers, editors, and the STS community at large for its longstanding presence. Thank you and congratulations S&TS! At 30 years of age, the journal stands among the oldest STS journals currently published. For example, *Science, Technology and Human Values was* began in 1967, *Social Studies of Science in 1970*, *Science as Culture* in 1987, *Science, Technology and Society* in 1996, and the *Nordic Journal of Science and Technology Studies* was published first in 2013.

Beginning and international developments

The first issue of Science & Technology Studies was published in 1988, initiated by the Finnish Association of Science and Technology Studies. At start, the journal was entitled *Science Studies*.

The journal was initiated by an international group with Finnish lead; it was aimed at global audiences but with particular inputs and aims towards strengthening Nordic STS. *Science Studies* was published biannually in English. In the first issue of the journal (1988), Veronika Stolte-Heiskanen, the first editor articulates this as follows:

> The last decades have witnessed a growing interest and increased research activity in the field of science studies in the Nordic countries... The (Finnish) Society decided that the time has come to establish a journal in order to disseminate information to an international public about research and ongoing discussion in science studies in Finland and in other Nordic countries...The aim is to eventually institutionalize the journal as a joint Scandinavian publication...our goals are to stimulate and strengthen science studies in the Nordic countries, to intensify contacts and exchange of ideas among scholars working in this field, and to inform the wider international scientific community about science studies carried out in the Nordic environment.

The journal internationalized rapidly, however. In 1994 the Nordic editorial board was complemented with members from beyond Scandinavia, to include, among others, John Ziman. In 2/2005, former Chief Editor Marja Häyrinen-Alestalo writes in an editorial that:

> The broad perspective that was adopted during the first years was a reflection of analyses made by the journal's Scandinavian authors. Soon, however, **we felt a need for broader internationalization.** We presented our plans to highly recognised international scholars and asked them to join in the project.

Throughout the 2000s, *Science Studies* grew by both published numbers and diversity: as the number of papers submitted to the journal increased, range of themes and concerns also

expanded. Hyysalo & Knuuttila write in an editorial in 2/2009 that "90% of our papers and reviewers come from outside Finland."

In 2011, the editorial team welcomed three international new editors, and has increased their number ever since, to the current number of nine editors (one of whom is also the coordinating editor), plus two book editors.

In 2012, the journal became the house journal of the European Association for the Social Study of Science and Technology (EASST). At this point the journal's name was changed to *Science & Technology Studies* to reflect its content that also addressed an interest in technologies. Moreover, it was felt important for the editorial team to reflect European diversity: a policy of Europe-wide representation in the editorial team was set in place.

In reflection of EASST's Europe-wide focus, the editorial team now comprises members from all major linguistic and national networks and hubs of STS: Nordic, German speaking, French-speaking, Dutch, British, Southern, and Eastern European regions. The journal does not aim to only to publish work by those situated in European universities, or research focused on Europe, however. The authors' locations underline the international reach of S&TS. Scholars publishing in S&TS span from being situated in universities across Argentina, Australia, Austria, Belgium, Brazil, Canada, Croatia, Colombia, Denmark, Estonia, Finland, Germany, Greece, India, Ireland, Israel, Italy, Japan, Mexico, Netherlands, Norway, Portugal, Slovenia, South Africa, Spain, Sri Lanka, Sweden, Switzerland, UK, and US. In terms of numbers, Europe, and north Europe in particular, is strongly present, with also large number of papers coming from Northern America.

As the long list of authors' locations attests to, the journal's content scope is global. Indeed, research is reported from further sites and locations as well: translation of STS concepts across different cultures, epistemic traditions, and systems of practice, also beyond the 'developed world', has been a topic that authors in S&TS have contributed to, e.g. in the editorial of Global Health and STS special issue in 3/2017; and the prologue by Amit Prasad in 4/2017. Work remains to be done, however, to encourage authors based in African countries to be present in the field and to reflect upon intersectionality in STS, both in the topics of study as well as STS's own knowledge production practices.

Special issues and key debates

The journal has contributed to new and emerging fields of STS, particularly by giving space to these ideas in special issues. The journal has published 15 special issues during the 30 years covering topics such as: knowledge infrastructures, university-society relations, global health, politics of innovation for environmental sustainability, energy in society, cultural analysis as intervention, gender at scientific work places, standardization and social texture, architecture, open source, feminist technoscience, computer models and simulation, ageing and technology, antiscientific sentiments, and evaluation. Exciting forthcoming special issues include numbers and numbering, citizen science, foreknowledge, and expertise.

Possibly owing to the journal's Nordic roots, arising from countries known for their gender equality, gender has featured prominently in the journal's content and editorial presence. Special issues topics have focused on developing feminist technoscience scholarship at large, and addressed gender relations in academic knowledge production. In addition to the special issues, numerous

Table 1. Author's locations 1988-2018

Continent	1988-1998	1999-2008	2009-2018	Total
Europe	100	120	262	482
North America	16	28	41	85
Australia	3	1	14	18
South America	7	4	4	15
Asia	5		5	10
Africa		1		1

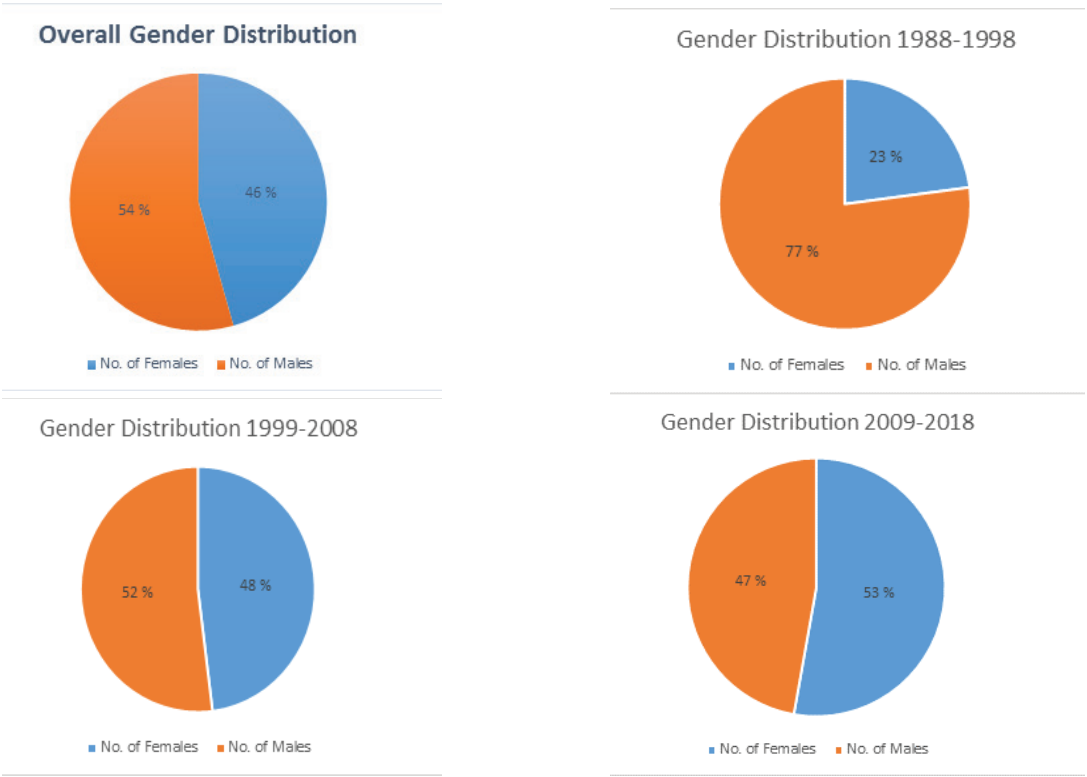

Figure 1: Gender distribution of S&TS contributors: the overall distribution and distribution of contributors according to decades. Compiled by Prerna Srigyan.

scholars have emphasized the persisting inequities in science and technology, shown how power operates in research networks, and the ways in which innovations gender and are gendered. If the journal's own numbers are an indication, of the current editorial team, 50% of the members are women and in the journal's history, four of the six coordinating editors have been women. Of the authors publishing in the journal throughout the 30 years, 46% have been women. During the first decade, the difference was as unequal as 77% of men to 23% women. More recently, however, since year 2009, the number of women authors becomes slightly higher than men at 53%.

Open knowledge

The journal is at the forefront open access publishing in STS journals. The entire archive of S&TS is free to download through the journal website, without embargo on any issues. The journal is also free to publish, meaning that the journal does not charge publication fees from authors. During the early years of the journal's association with EASST, the last issue was reserved for EASST members as a member benefit. The council debated the role of publishing as a 'commons', however, as something that should be available all of those interested in STS as a field, rather than restricted to paying members. As a result of these conversations the embargo was removed and in 2017 the journal became fully open access.

The journal is published without ties to commercial publishing houses. The publication is managed on an open source software based platform called Open Journal Systems (OJS) that is developed by the Public Knowledge Project. Open access is possible thanks to the financial support of EASST and the Finnish Science Foundation via the Finnish Society for Science and Technology Studies.

Once again, thank you for all readers, writers, reviewers, guest editors, and editors of *Science & Technology Studies*. For fruitful years ahead!

Lost in Translation: Czech Dialogues by Swedish Design

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Abstract

This study explores the journey of a model for stakeholder involvement called RISCOM. Originally developed within the field of radioactive waste management in Sweden, it was later used in the Czech Republic to re-establish public dialogue in the process of siting a geological repository. This case offers an opportunity to empirically study the fragility and ambiguous results of organized spread of public involvement across various domains of technological innovation and national contexts. We show how three circumstances – (1) the ambition to make RISCOM an internationally used model for public dialogue, (2) the specific situation in the Czech siting process, and (3) the short-lived and limited success of the subsequent Czech dialogues by Swedish design – were intrinsically related and sustained each other. Better understanding of such complexities might contribute to a more realistic attitude toward technologized democracy, i.e., toward practices of public deliberation increasingly becoming instrumental, transferable, and depoliticized.

Keywords: socio-technical controversy, public dialogue, nuclear waste management, sociology of translation

Introduction

Transferring an elaborate design to a different setting and putting it into use out of its original context is an intricate business with uncertain results. We take this well-known STS lesson (Bijker and Law, 1992; De Laet and Mol, 2000; Nielsen and Jensen, 2013) as a starting point for our case study on stakeholder involvement. We discuss how an established participatory procedure is made to travel from one national context to another. We are interested in how the 'technology' itself

is being transformed or *translated* during its displacement. Thus, we mobilize the relatively well-established imagery of technology transfer for the purpose of studying how formalized public involvement models are being spread across the EU. We argue that potential consequences of these activities can be problematic in specific ways. Namely that technologies of participation, transferable from country to country under supervision of participatory experts, may easily contribute to instrumentalization, depoliticization, and emptying of deliberative politics.

To make this argument empirically grounded, we present and critically discuss the story of how a Swedish design for public dialogue called RISCOM[1] was transferred to the Czech Republic. RISCOM, as a set of principles and recommendations for structured and transparent communication among stakeholders, was originally shaped during public debates on geological repositories of high-level nuclear waste in Sweden. After some time it entered the international arena: as part of several European projects it was proposed to facilitate – and democratize – siting processes related to planned geological repositories in the Czech Republic and other East European countries. We will show that, on the one hand, RISCOM made an important achievement in the Czech case, since it helped to bring all the main actors to a discussion table after previous negotiations had completely crashed. On the other hand, RISCOM failed from a broader and more subtle perspective. Its application contributed to the subsequent shift toward more authoritative decision-making and another crisis of mutual trust in the Czech repository siting process.

The case study on RISCOM was part of a broader collective work on the European Commission (EC) funded research project InSOTEC.[2] Our data consist of documentation, interviews with key actors, and observations of various meetings and events. Data relating to the Czech Republic were collected by Zdeněk Konopásek and Karel Svačina and the Swedish data were collected by Linda Soneryd. RISCOM was first implemented in the Czech Republic within an EC funded project Arenas for Risk Governance (ARGONA, 2006-2009). Soneryd was involved in the ARGONA project studying the development of RISCOM in Sweden (see Elam et al., 2008). The implementation of RISCOM in the Czech Republic, Poland and Slovakia was also an element of yet another EC-funded project Implementing Public Participation Approaches in Radioactive Waste Disposal (IPPA, 2011-2013). Several participants in the IPPA project were also members of the InSOTEC research team. On the one hand, the existence of this concurrent implementation project provided us with many useful exchanges and experiences. On the other hand it situated us into a rather delicate situation. By critically analysing the efforts to implement RISCOM in the Czech Republic, we were necessarily and openly putting in question some key aspects of these EC-funded efforts. Despite this, all the concerned colleagues were willing to talk and discuss. We very much appreciate their collaboration under such circumstances.

On translation and treason

We suggest that the Czech dialogues by Swedish design need to be assessed against complexities that unfold before our eyes as soon as the process of transferring RISCOM from one setting to another is understood as its *translation*. The concept of translation is a crucial part of the vocabulary associated with actor-network theory, ANT (Callon, 1986; Latour, 1986) and with ANT-inspired studies of technology transfer in particular (e.g. Law, 2006). Simply put, actor-network theory helps to understand how success or failure – in terms of truth, continuity, durability, resistance or reality – is practically and specifically achieved. How is it that things come to work? More specifically, in relation to the problem of technology transfer, how does it happen that some technology is effectively transmitted to a new setting? The general ANT-like answer is: because it was translated. In relation to our specific subject, to articulate RISCOM anew, in a new setting, means articulating it differently.[3] The issue is not that one simply has to adapt the transferred technology to meet new conditions and requirements. The process of translation always involves "displacement, drift, invention, mediation" and the creation of links "that did not exist before" that modify ele-

ments or agents since they are combined in new ways (De Laet and Mol, 2000; Latour, 1994: 32).

Thus, by definition, there is no transportation without transformation. It does matter, however, what specific transformations occur and how. Translation can be good or bad, better or worse. Faithful or unfaithful. Processes of translation always in some sense entail betrayal or treason (Galis and Lee, 2014; Law, 1999), more or less. We can therefore talk about failure. Or success – if the translation is done well.[4] In our case, for instance, the communication model transferred to the Czech settings may or may not function in the same (expected) way as the 'original' Swedish RISCOM. Or, eventually, the involved actors may even start doubting to what extent the object in their hands metamorphosed into something else, into a completely different procedure deserving its own name and identity.

Thus, locating a technology in a new context is a complex and risky movement, involving subtle transformations, by necessity not only of the travelling object itself, but also of those who want to make it travel and those who want to use it in the new settings (Callon, 1986). The perspective of translation allows us to look at the case of RISCOM's transfer with an understanding of its complexities and ambivalences. We believe that such an understanding is important for a critical, and yet constructive analysis of contemporary participative practice. Moreover, following the intricate trajectories of the RISCOM story offers a specific opportunity. With the help of the concept of translation, we hope to avoid picking up perhaps the easiest possible explanation of what happened to RISCOM on the way to the Czech Republic, namely that a well-established element of democratic culture was simply confronted with the underdeveloped (post-communist) political culture in the target country.[5] Although such an explanation would not completely miss the point, it would definitely miss the opportunity for a broader lesson about stakeholder involvement – about what happens when it becomes a piece of political technology, eventually transferable across borders and various settings.[6]

Spreading public involvement models: Technologizing democracy

Stakeholder involvement and public participation has become a yardstick for the quality and legitimacy of governance across a number of policy domains.[7] Celebrated in general, participation nonetheless attracts critical attention of contemporary analysts (e.g., Irwin, 2006; Sundqvist, 2014; Wynne, 2007). In our paper we join these critical examinations by focusing on how the expansion of forms for invited participation like RISCOM can turn public involvement into a predominantly technical issue.

This 'technological' aspect of participation is of course nothing new. No matter that conflicts intrinsically belong to politics (Hirschman, 1994) and that a conflict often directly precedes, as a triggering event, the introduction of professionally orchestrated deliberative exercises, invited public involvement is often framed as attempts at *neutralizing, avoiding or preventing controversies* (Kleinman et al., 2011). The organizers of these events expect from them that they would serve as lubricants with the help of which the entire decision-making machinery runs smoother and less contested. Public deliberation then gets emptied from its political nature. Indeed, it gets depoliticized. As noted by Andrew Barry (2001: 7), "the deployment of technology is often seen as a way of avoiding the noise and irrationality of political conflict" – and this is true even for technologies of participation.[8]

The idea of technologized public deliberation events significantly relates to what Alexander Bogner (2012) terms 'lab participation': "a form of participation organized by professional participation specialists, taking place under controlled conditions and largely without reference to public controversies, political participation demands, or individual concerns" (Bogner, 2012: 510). Lab participation is characterized by being often organized in the context of a research project and funded by a third party, and by being very well-documented. Since respective events neither have been initiated or framed by public concerns nor have any impact on decision-making and seldom invite grassroots activists or NGOs, they are said to "bear practically no relation to the world outside" (Bogner, 2012: 511). According to Bogner, lab-

participation has deeply paradoxical and not quite convincing results. Bogner's concept is particularly relevant for us, since a 'laboratory' character of RISCOM, as we will explain soon, was explicitly formulated as one of its founding characteristics. In other words, RISCOM was *intended* and specifically designed as lab participation – and as such, with real effects in the political realm. Our case may therefore be taken as an opportunity to elaborate Bogner's arguments and specify them further.

The laboratory nature of the RISCOM model

The background ideas of RISCOM are inspired by a simplified version of Jürgen Habermas's theory of communicative action in combination with elements of organizational theory (Espejo, 2007). The design is based on a set of principles[9] and practical recommendations[10] for making communication between stakeholders structured, transparent and meaningful. Among other things, it establishes a 'Reference Group' and a 'Working Group' within the Reference Group. All the participants, i.e., the project team and members of the Reference Group, have to sign agreements that oblige them to comply with the RISCOM principles.

RISCOM is therefore rather similar to many other recommendations for public dialogues about controversial issues. It is unique, however, by certain laboratory qualities, explicitly formulated and often emphasized by its authors. Since the beginning, it has been crucial for the RISCOM design that the involved parties feel that it is safe to enter the dialogue. To achieve such an effect, RISCOM tries to create a specific deliberative "neutral arena" (Andersson and Wene, 2006), which has the form of a *contained* environment, established *temporarily* by the organizers to get the participants *dis-connected* from real-life politics and decisions. Within this laboratory space, participants commit themselves to act as equals, united by the respect toward 'fair dialogue'. By means of such dialogue participants expose themselves to a challenging, and yet friendly mutual stretching. With the help of stretching "the force of the better argument" should become manifest and participants' perspectives may eventually get enriched, shifted or even shaken. After RISCOM finishes its work, the stakeholders return to the realm of political struggle *subtly transformed* by the experience of a 'politically neutral' dialogue, in which everything can be freely expressed, without the constraints of specific political tasks or interests (e.g. Andersson et al., 2011).

To sum up, the specific value of RISCOM is based on the idea that it allows what ordinary political engagement does not allow: unconstrained exchange of arguments and views between equals. We could therefore understand RISCOM as a true and *explicit* lab-participation experiment in Bogner's (2012) terms. Temporary detachment from real politics is, in fact, the main and even acknowledged effective force here, at least in theory.

The Swedish life of RISCOM

Nuclear waste management in Sweden[11] has enjoyed a reputation of being more open and participatory than in many other countries (Dawson and Darst, 2006). During the 1980s, however, the search for a suitable place for nuclear waste disposal was a technocratic endeavour insensitive to citizens in the concerned municipalities (Elam and Sundqvist, 2011). With the aim to gain more knowledge of the Swedish bedrock SKB (Swedish Nuclear Fuel and Waste Management co) made studies that included drilling, without the consent of the municipalities and with very insufficient information given to the population. This resulted in fierce local protest and the implementer SKB had to stop the drillings before the investigations were completed. It was impossible for the nuclear waste company to continue with its investigations and SKB changed its strategy to a 'voluntary approach' (Elam et al., 2010): in 1992 the company sent a letter to all municipalities and asked if they were welcome to make site-investigations. The letter made clear that the municipalities that allowed the company to make feasibility studies were neither obliged to agree to further investigations nor to host a nuclear waste disposal facility.

Around the same time the government authorities (the Swedish inspectorate for nuclear activities, SKI, and the Swedish Radiation Protection Agency, SSI) made their own interpretation

of the situation. The local protests had created a stalemate in the siting process, and it was obvious that ensuring the quality of the bedrock was not enough: acceptance was equally crucial. This insight made the government authorities turn to dialogue. With the aim to explore what a siting process could look like that all actors could perceive as legitimate, the Swedish inspectorate for nuclear activities started the Dialogue project, which was a direct predecessor to the RISCOM model (SKI, 1993a; 1993b).

The Dialogue project took place over a few years in the beginning of the 1990s. It involved environmental organisations, municipalities and government authorities and it was organized as a simulated review process of an application concerning the final disposal of nuclear waste, seeking permission to construct a final disposal system (SKI, 1993a). SKI funded the project, hoping that it could lead to a common view around the decision-making process and a credible review process in the future.

The government authorities then continued to refine a design for dialogue through two research projects. RISCOM I (1996-1998) explored how nuclear waste management could be more transparent and engaged basically the same people that were involved in organizing the Dialogue project. RISCOM II was an EC funded research project (2000-2003) and involved testing the design for public dialogue on radioactive waste management in other countries. A few years later RISCOM guided public dialogue on another highly controversial issue – the planning and building of a new infrastructure for mobile telephone communication (Soneryd, 2008; Lezaun and Soneryd, 2007).

After this short excursion into a non-nuclear issue, the RISCOM model found its way back to nuclear waste again, when the Nuclear Waste Council decided to set up a Transparency programme during the late phases of the site selection phase. The aim of these hearings was to open up questions of relevance for long-term safety that had been little discussed at the public consultations organised by the nuclear waste company SKB, for example the question of alternative technical concepts.

Overall, RISCOM and related dialogue forms have been relatively marginal to nuclear waste management in Sweden (Elam et al., 2008; Elam et al., 2010). Although the government authorities SKI and SSI have approached stakeholder involvement rather openly from 1990s and onwards, the nuclear waste company SKB has not shown much interest in RISCOM. The limits of the dialogue can be also seen in the lack of direct impact on real decision-making. Even if some of the RISCOM activities – for example the Transparency Programme organized by the Swedish Nuclear Waste Council (2007-2010) – did raise some challenging issues, they never seriously challenged the pre-eminent position of SKB's RD&D programme (cf. Elam and Sundqvist, 2009).

RISCOM travelling to the Czech Republic

The RISCOM model came to the Czech Republic in the middle of a governmental moratorium on the process of siting geological disposal. This moratorium was declared in 2004, after previous negotiations had failed.[12] The state agency RAWRA and the Nuclear Research Institute were invited to become participants in an EC project ARGONA (2006-2009), headed by the Swedish author of RISCOM.[13] One of the main aims of this project was to "test and apply approaches to transparency and participation by making explicit what it would mean to use the RISCOM model and other approaches within different cultural and organizational settings" (see ARGONA, project summary, undated).[14] In order to achieve this, a 'Reference group' was established in 2008. The group brought together various stakeholders from state organizations, municipalities, and NGOs.

The moratorium was concluded by an international conference called "Towards geological disposal without conflict" organized by RAWRA in November 2009. This event represented a 'turn' in the approach of RAWRA as the key implementing state organization. After technocratic measures, protests and moratorium, emphasis was now put on negotiation and dialogue. Representatives of RAWRA started to emphasise that without the consent of the municipalities, they would not go forward with site investigations. RISCOM and the

ARGONA project were quite important topics at the conference: several speakers appreciated their role in the Czech Republic, and called for continuing similar activities.

In about a year after the ARGONA project ended the RISCOM Reference Group found a successor: a national "Working Group for dialogue about geological disposal" (WG) was established. It was initiated by RAWRA as an advisory body of the Ministry of Industry and Trade, seemingly outside the experimental logic introduced by the original RISCOM. But it was in many respects similar to the former Reference Group and already during its first meeting it was suggested that the WG might become associated with a new EC-funded project, IPPA, which was just being prepared and for which the implementation of RISCOM in several post-communist European countries was a key task (Andersson et al., 2011; see also IPPA, undated). Although some members of the group did not necessarily have to be fully familiar with or even aware of RISCOM (research interview, 2012), WG's key representatives clearly considered the WG as a direct successor of the ARGONA project's Reference Group and as a part of RISCOM (and IPPA) activities in the Czech Republic (research interviews, 2011, 2012). Also according to the official IPPA report, "The Working Group was founded on the RISCOM principles" (Vojtěchová and Steinerová, 2013: 2) and RISCOM became the engine of the entire dialogue among stakeholders in the Czech siting process (Vojtěchová and Steinerová, 2013: 22).[15] The WG had therefore two faces, unreflectively combined together.[16] It was to offer a RISCOM-like *safe space* – an environment where the participants could "meet, peacefully, without any extra goals... that could restrain or push the participants" (research interview, 2011). At the same time, however, members of the group tried to develop the agenda of an advisory body (commenting legislation and policy materials).

The WG met eleven times between 2010 and 2013. However, already in 2011 there seemed to be growing frustration among members of the WG. Mayors of concerned municipalities increasingly felt that the entire dialogue had become empty and just for show. The Ministry of Industry and Trade was showing more and more neglect toward what was happening inside the WG, which was repeatedly noted with uneasiness in minutes from WG's meetings. While mayors often expressed their dissatisfaction relatively openly, similar attitudes were tacitly developing among the Ministry people too, which became fully manifested later on.

As a result, participants in the WG increasingly started to act beyond the group's framework, which only contributed to mutual frustration. Both mayors and NGO people complained that even if an agreement on something is achieved within the WG, it does not mean anything since it is sooner or later rolled over by informal backstage negotiations outside the WG. But they themselves started communicating outside the WG too, like in earlier times, for example by means of a separate and confidential e-mail list. In this communication some of the opposing mayors called the body a "Potemkin's group". The WG simply began eroding and overflowing on several sides. Nevertheless, the integrity of the WG was still kept by the repeated claim of RAWRA that it would not proceed with the planned site investigations against the will of concerned municipalities. This was taken as a key guarantee that 'fair dialogue', however ineffective and emptied, would continue. At the same time, partners of the EC-funded project talked in front of international audiences and in the project reports about the success of RISCOM in the Czech Republic (e.g., Andersson, 2012a).

The course of events got more dramatic in mid-2012. At that time, as a result of bilateral negotiations between RAWRA and individual municipalities and with the support of approved financial compensations, it seemed that local governments at two candidate sites were going to sign the contracts for site investigations. In response to this, local opposition intensified and new referendums eventually refused the site investigations. This was a blow for the state administration, which was apparently hoping that the site investigations might finally become more widely accepted and that further steps toward the repository could be taken. At that moment, in fact, the Ministry of Industry and Trade, the parent institution of RAWRA, lost patience. Without prior caution it changed the direction back toward an authoritative, expert-driven decision-making. It

openly dissociated itself from RAWRA's strategy focused on dialogue. It was decided to apply for the site investigations even without the consent of concerned municipalities, regardless of the key promise RAWRA repeatedly gave within the WG.[17]

The trust of municipalities and NGOs was deeply shaken by these events. They perceived the situation as a return to the years before the moratorium. The WG almost ceased working. While RAWRA declared its interest in continuation of the WG, at least formally, the others hesitatingly agreed with further work on the condition that the status of the WG would change into a more action-oriented body. In addition, a background material for the revision of the governmental "Strategy for nuclear waste management" asked for a deep transformation of the existing WG too. It suggested, for instance, that those who are not seriously interested in "constructive negotiations" about the repository should be excluded from the WG (NRI, 2013). In short, the WG was most probably either going to be fully transformed into something else or completely abandoned.[18] The IPPA project, presenting the WG as the RISCOM Reference Group, was to end in 2013. One of the last IPPA reports (elaborated by two Czech participants), in its Recommendation section, does not refer to RISCOM at all anymore (Vojtěchová and Steinerová, 2013). Experiments with dialogue among equals evaporated. 'Clarification of arguments' and 'mutual understanding', so emphasised by RISCOM, but followed inconsistently already before, were completely abandoned.

To sum up, it is clear that the trajectory that started under the auspices of EC and with RISCOM is over.[19] This trajectory initially raised high hopes, but ultimately made *all* the participants of the process frustrated. RAWRA, as a key local proponent of RISCOM-like dialogue, got almost extirpated.[20] Not only municipality representatives and activists, but also Ministry people and technical experts were increasingly dissatisfied with the situation.[21] Much of the frustration came from what seemed to be an ineffective dialogue leading to nowhere. And even the leader of the IPPA project and Swedish author of RISCOM suddenly started talking only with hesitation about how RISCOM was implemented in the Czech Republic (personal communication, 2013). RISCOM as a widely applicable technology of participation was left, in this particular case, alone and questionable.

Translating the RISCOM model

How can we understand this RISCOM story? How can we interpret the attempt at transferring the model from one context to another as a complex movement of translation? A simple explanation of the failing dialogue described above might refer to different political cultures, legal frameworks and other context conditions. In Sweden, for example, the municipalities involved in the siting process have a relatively strong position compared to the municipalities in the Czech Republic. In the Czech Republic, moreover, there are many municipalities on each preselected site, which makes negotiations more difficult than in sparsely populated areas of Sweden. In general, it is tempting to assert that RISCOM failed because, being based on the highly advanced Swedish (or Western European) democracy, it simply did not fit well into the specific Czech setting, with all the legacies of communist rule and with the blindness of Czech authorities and policy makers toward the centrality of the public in the entire process (Dawson and Darst, 2006). Let us put, however, such explanations aside (which does not mean dismissing them!) and try to understand the situation even more subtly.

How the Czech siting process and RISCOM became attractive to each other

When the Czech governmental moratorium was coming to an end, it was clear that the siting process had to be restarted on new grounds. However, RAWRA did not quite know what to do. Although it already had the experience with public protests, which preceded the moratorium, it was still basically an engineering organization, full of technical specialists, without the experience of engaging in a public debate. In this situation, RISCOM came as a light at the end of a tunnel, showing a possible way to proceed out of the deadlocked situation. It provided an opportunity to start anew on a relatively widely accepted basis. In fact, RISCOM provided RAWRA with a new identity: with the help of ARGONA and related

efforts, RAWRA became the main guarantor of the newly adopted approach and the dialogue with municipalities became its main mission. At this point in time, geological projects of RAWRA were suspended (see RAWRA Annual Reports 2004-6 available at SURAO, undated), and "everyone [at RAWRA] became engaged in communication with the public" (research interview with a RAWRA employee, 2011).

This transformation of RAWRA was necessarily limited. The personnel remained basically the same and it lacked sensitivity toward democratization in technical innovation.[22] RISCOM, as a seemingly transferable ready-made procedure for how to facilitate public dialogue, therefore looked particularly attractive. By adopting the Swedish technology for public dialogue, RAWRA was able to replace the technocratic view that there are no reasons to involve the concerned municipalities with the conviction that achieving the consent of local people is something basically technical and manageable.

An important thing was that RISCOM came to the Czech Republic as 'the Swedish model'. Since the early stages of the Czech siting process, Sweden had often been referred to, implicitly and explicitly, as the role model in deep geological repository development.[23] In official presentations as well as in our interviews with Czech stakeholders it was implied that RISCOM was widely used in Sweden, and that it lead to successful siting of the repository. This was, let us remind, somewhat contradictory, first, to the original framing and practice of RISCOM events as experimental, and second, to the relatively marginal position that RISCOM had in Swedish radioactive waste management.

It was only perfect that RISCOM appeared as something *imported*, and not invented or designed by a direct participant in the deadlocked Czech situation. In the eyes of the public, RAWRA had been discredited by that time, and the concerned people did not trust the implementers. Anything 'made by RAWRA' would have seemed suspicious. Further, RISCOM was not just a product of a 'third party' (a well-tested product, it was believed), but it was introduced to the Czech situation *together* with a third party – i.e., international mediators, relatively detached from the ongoing conflict. This helped to neutralize the situation and get the involved parties to sit at one table again.

Not only the implementers regarded this Swedish import positively. Also the NGOs expressed a cautious optimism. Activists were unhappy with how the negotiations between RAWRA and the municipalities had been carried out, and they saw the introduction of RISCOM not only as "one of the first attempts at transparency", but also as an opportunity to show "how untransparent and wrong the way of doing the whole thing here" had been (research interview, 2013). Furthermore, the activists often refer to Sweden as an example of a desirable *voluntary* approach; the possibility of Swedish municipalities to decline the project throughout the entire siting process was appreciated and put in sharp contrast to the Czech reality.[24] RISCOM, as 'the Swedish approach' was therefore welcomed also by other stakeholders.

The Czech situation at the time of the moratorium was very attractive for the Swedish RISCOM implementer too – and for related reasons. The attractiveness (or "interessement", as Callon (1986) would put it according to his sociology of translation) was mutual. We mentioned above that the inventors and proponents of RISCOM had the ambition to systematically develop the model into a universally applicable procedure already in the early Swedish life of RISCOM. For them, European research and policy projects provided unique application opportunities. Post-communist members of the EU constitute an especially good market for such services. Public deliberation in complex socio-technical controversies represents a relatively new challenge for policy makers in these countries. The state administration is often unprepared for possible conflicts, lacking qualified personnel and resources. And if it eventually happens, like in our story, that public initiatives get furious and irritated in response to some careless technocratic decision-making, policy makers become eager to participate in public involvement projects. No wonder that such countries provide a rewarding terrain for foreign public deliberation professionals, a genuine laboratory for testing new democratic approaches.

Adopting the RISCOM principles and making them empty: From stretching to safe space

When talking with the Czech participants it was clear that all of them had heard about RISCOM, or at least about 'the Swedish approach'; but hardly anybody was able to explain what exactly RISCOM was and how it was supposed to work. RISCOM was therefore widely accepted in the new setting mainly as *a general appeal* toward fair dialogue, and not as a strict experimental or laboratory form of deliberation.

It was easy for the Czech stakeholders to adopt RISCOM in such a non-specific form, since everybody had been frustrated from the protracted non-communication and general distrust. The prospect of sitting around a table and just talking to each other, bounded by the rules of mutual respect and under the supervision of a relatively independent moderator, looked very refreshing and attractive (research interviews, 2011, 2013). Thus, the RISCOM framework became quickly accepted and shared by all the participants without contestation – but only at the cost of losing important specificities of the model.

But RISCOM was not only de-specified, it was also emptied. As noted above, activities within the newly established stakeholder groups quickly turned into a dialogue for dialogue. In the beginning of the ARGONA project the stated aim was "to increase common knowledge of *all aspects* related to siting geological disposal with the goal to increase transparency and engage public in the decision-making process" (Minutes of the first Reference Group meeting, 13 May 2008, available at SURAO (undated) – emphasis added). This never really happened though. Whereas in Sweden some RISCOM activities included discussions about, for example, alternative technical options (such as deep boreholes), the Czech debate within the WG focused mainly on the status of the group itself and, generally, on how to strengthen the legal position of municipalities in the siting process. Geological and engineering aspects were left out of the debate, while the only relevant issue became how to obtain agreement with the concerned municipalities. Indeed, "feelings of people" (NRI, 2013: 76), and not alternative technical solutions, became the primary target during this dialogue-phase of the siting process.

The tendency toward emptying the dialogue (by means of making it acceptable and workable in the new setting) can be observed in a number of ways. Let us take, for example, the following shift. In official presentations, the authors of RISCOM used to emphasize 'stretching' as a crucial concept and activity within the RISCOM model (Andersson, 2011, 2012b). Stretching is explained to mean publicly "testing and challenging the claims put forward by the proponent and the relevant authorities" (Westerlind and Andersson, 2004: 1). However, in our data we have not found any signs of stretching being actually applied during the Czech RISCOM activities. This concept is neither mentioned in any of the materials produced by the WG, nor was any of the meetings we have visited or heard of organized around stretching practices. Stretching simply did not seem to play any important role in the Czech part of the project.[25]

While the importance of 'stretching' was diminishing during the introduction of RISCOM in the Czech Republic, another notion was gaining more and more significance: the notion of 'safe space' (for dialogue).[26] Safe space can be understood as a precondition for stretching; then it would be a space where participants do not feel threatened by possible conflicts and pressures to reach decisions so that stretching may become as challenging as possible. However, *without stretching*, safe space easily becomes *a space where nothing important happens* – a space serving those who actually do not want to engage in an effective, change-producing dialogue. And this was far away from what the Czech stakeholders (not only municipalities and NGOs, but also the Ministry) ultimately expected from the dialogue. As already mentioned, the participants, as soon as their pleasure from dialogue in general had gone away, became frustrated by the fact that negotiations within the WG had almost no real consequences and the RISCOM-like space of the WG was simply 'safe' mainly for RAWRA.

Therefore, we can see that a shift in emphasis from 'stretching', which remained an opaque expression for the Czech participants, to 'safe space' contributed to a rather legitimate feeling

that the dialogue did not have direct impact on the situation. Let us remember, nonetheless, what was discussed in one of the earlier sections: the RISCOM style of dialogue was by definition intended to be politically irrelevant, so to speak. At least in terms of immediate consequences. As a deliberately laboratory dialogue, temporarily established outside of real-life politics, *it is to be*, in the sense of practical politics, for 'nothing'. So where is the problem?

From a marginal, supplementary procedure, to the main vehicle of political deliberation

RISCOM's laboratory character was obvious and clearly articulated when RISCOM started its life in Sweden. Already the Swedish Dialogue project was explicitly organized as an experiment. It was organized as a role-play in which participants reviewed a fictitious application from the nuclear waste industry to build a repository at a hypothetical site. In the report the fictional character is emphasized in phrasings such as: "the transfer of the experiences from the project to a *real* review process will require a continued dialogue between the *real* actors" (SKI, 1993a: 12, emphasis added).

RISCOM organized within the ARGONA project in the Czech Republic resembled a 'lab participation' exercise in many respects (Bogner, 2012): it was led by participation professionals; the participants were made to sign formal agreements; it was organized in the context of a research project and funded by a third party; and it was well-documented and subject of further research. The aim of ARGONA was "to test and apply approaches to transparency and participation in decision-making process within the participating countries" (Vojtěchová, 2009: 3). All this was in line with previous RISCOM projects.

One important thing was different though, largely unnoticed.[27] Originally, in Sweden, RISCOM was one of many forms of public dialogue or participation. As such, it was rather complementary. As Elam et al. (2008) put it, RISCOM had the function of being repair work to SKB's failures – by opening up issues that threatened the legitimacy of the nuclear waste programme if they had continued being silenced and neglected (Elam et al., 2008; see also Elam et al., 2010). Only under such conditions, the specific laboratory design of this procedure makes sense. Participation in RISCOM provides a unique experience, not available 'in the wild', namely that it pulls the stakeholders out of the political turmoil, putting them into artificial conditions of a fair and safe Habermasian dialogue. Such dialogue may enrich participants' perspectives, clarify their arguments and make them better prepared for practical political negotiations *after* the project is over. In order to work, therefore, the utopia of RISCOM has to be established *temporarily* and as a specific *complement* to real political negotiations. A dialogic exercise of this kind cannot *replace* actual negotiations and democratic decision-making. It makes sense only as an accompaniment of it, an extra with specific added value.[28]

In the Czech Republic, however, RISCOM became associated with *the* main and sometimes the only recognized form of actual public dialogue, the Working Group – a true showcase of the turn toward a more democratic approach. Put differently, the distinction between the inside and the outside of the RISCOM space, emphasised by RISCOM inventors as the effective force of its approach, was not maintained in the Czech setting. The Czech RISCOM, contrary to the situation in Sweden, had simply *no outside*. It became integral to the only recognized deliberative forum, the WG. RISCOM's possible specific import, as an experimental dialogue separated from real-life politics, could not be fulfilled.

In conclusion: Democratic participation in and out of the laboratory

Was RISCOM translated successfully? Talking about success and failure is always a delicate thing: success or failure for whom and within what time frame? Seen as a clearly demarcated model, as a stable, strictly defined and tightly controlled experimental object, RISCOM can never fail. Its failure can always be explained by the fact that the RISCOM model was not implemented properly and as strictly as possible (and thus failure must be ascribed to something else).[29] The actor-network logic of translation, however, imagines a different

RISCOM. While travelling from case to case, from one country to another, RISCOM was being transformed by contributions of *many hands*, more or less directly responsible for these movements.

Especially when located far away from the Swedish reality, e.g., in meeting rooms in Prague, RISCOM quite visibly ceased to be an exclusive creation of its original authors, and was redefined and reshaped by other actors too. Most of the Czech participants did not actually intend to import a specific and rather supplementary element of a broad range of public involvement techniques. Instead, some were interested in RISCOM simply as an embodiment of the 'successfully' accomplished process of siting in Sweden (not quite correctly); others saw it (quite misleadingly) as something associated with the spirit of voluntary approach, within which Swedish municipalities were treated with much more respect and care than was the case in the Czech Republic. Yet, it cannot be concluded that the Czech stakeholders simply misunderstood the essence of RISCOM, violated its key principles and, in fact, implemented – badly – something else. The very original Swedish authors of RISCOM were pretty close to the entire translation process, an important part of it, indeed. They actively pursued their own interests while translating RISCOM along this particular trajectory, using all the respective transmutations for their own purposes. These purposes had nothing to do with preserving RISCOM, at all costs, in its original contours, but rather with developing it into an internationally relevant tool that could be repeatedly applied and tested in different countries (see, e.g., the IPPA project and its key reports).

How to understand the story of RISCOM's translation then? Initially, the ARGONA project brought something really new and refreshing to the Czech situation. RISCOM offered an attractive political fiction, which seemed to bring a true and practical relief from serious personal and social tensions related to the deadlocked controversy and years-long moratorium. But this could not take long. Turned into a rather general appeal to fair dialogue and transparency, RISCOM soon became a rather empty deliberative exercise. This introduction of RISCOM into the Czech environment, under the direct supervision of its authors, deprived this peculiar lab-style dialogue from the only meaningful context it could have. Actors on both sides of the controversy got increasingly frustrated by what seemed just for show and without palpable results and at the same time the only platform for negotiations.

One should note that the Czech participants did not fully understand and appreciate the subtle potential impact of RISCOM, simply because they really could not do so – and the reason was not (just) that RISCOM was badly explained to them by its author, but rather that RISCOM had substantially changed: it had lost some of its specific contours and properties while relatively new emphases emerged. Originally, RISCOM was an avowedly laboratory experiment with quite limited, specific and subtle relevance in real-life politics. During the transport through two European projects to the postcommunist context it was translated into a universal technology that raised high expectations, which were necessarily betrayed later on. It came to be understood by the implementers as a major tool that would help them to obtain the consent of the concerned municipalities in a democratic way. It was, in fact, a matter of compromise *on both sides*: RISCOM was adopted in the Czech Republic only at the cost of becoming something else than originally intended in Sweden; RISCOM-related projects succeeded only due to betraying the strict version of RISCOM. This transformation of RISCOM was not an unanticipated side-effect of the travel but rather a key element of what made the transfer possible – only this new RISCOM could be interesting to the main Czech stakeholders, practically manageable and, in a specific way, successful. But, let us stress once more, it cannot be said that the Czech users simply mistook RISCOM for something else. Its key original author and designer did not leave RISCOM to its own destiny. He not only actively participated in the translation of the Swedish design of RISCOM into the Czech one, but was also dependent on the fact that these translations were (as successful interventions) part of the EC-funded implementation projects. It has been, after all, by means of these projects that RISCOM was actually becoming internationally applied "as a platform for decision making in [various] complex issues" (Karita Research, undated).

With all respect toward the complexity of the above described movement we may therefore talk about a failed translation, a treason. As Callon (1991: 145) explains: "A successful process of translation […] generates a shared space, equivalence and commensurability. It aligns. But an unsuccessful translation means that the players are no longer able to communicate. Through a process of alignment they reconfigure themselves in separate spaces with no common measure". And this is exactly what happened in our case. Not only the identity of RISCOM was loosened and challenged, so that one may doubt whether the model actually was not transformed into something else throughout the translation. The initial alignment of dialogue, so promising right after the end of moratorium, dissolved too: ultimately, RAWRA survived the collapse of dialogue only by another radical redefinition of itself; the Ministry 'forgot' its constitutive relationship to the WG, while the WG started eroding and renegotiating its status; RISCOM does not seem to have future in the Czech Republic – after all, the authors of RISCOM partly dissociated themselves from recent developments in this country. It is hard to tell, clearly and unambiguously, who was responsible for the betrayal. The translation definitely could have been done more faithfully, in collaboration with all participating actors, but probably – given their partial perspectives and the complexity of the situation – not *much* better.

Several elements in the story of RISCOM fit surprisingly well together, quite seductively: the EU's urge to strengthen democratic elements in socio-technical decision making; the ambition of a public deliberation professional to develop RISCOM into a universally applicable technology that can be transferred from case to case and from country to country; pressures to succeed in this kind of lab-participation projects;[30] the complicated situation of the Czech government which wanted to overcome the resistance of concerned municipalities as quickly as possible and yet in a democratic way; mayors from concerned municipalities and activists who desperately needed allies authoritative enough to push the Czech decision-makers to take their position seriously - these are just a few key circumstances of this complex case that have led to this *understandable misunderstanding* and the resulting state of 'lost-in-translation'.

More generally, we can see the story of RISCOM and of implementation projects such as ARGONA and IPPA as an example of a rather strong tendency toward technologization and specialization of public involvement. This tendency is based on a recent relative success of pressures toward democratization of science and technology (Felt et al., 2007; Liberatore, 2001). While it is widely recognized that decision-making in complex socio-technical arenas should be open to concerned lay publics, the long-established power practices are extremely resilient and it is difficult to replace them with a less technocratic political culture. Many therefore feel tempted to spread democratic governance by means of controlled and almost scientific implementation of ready-made procedures, models or techniques, firmly in grasp of experienced professionals.

This temptation seems especially strong in cases where a kind of democratic or deliberative deficit is obvious. Here come genuine 'technologies of participation': models of participative procedures, carefully orchestrated from above for those who are invited; but also, even more importantly, models that are capable of travelling – i.e., that can be used, under specialized supervision, repeatedly and outside their original contexts. The technological nature of these political tools and their transferability go hand in hand, constituting each other. That is why we believe that paradoxes of invited participation, addressed by Bogner (2012) and many others, are particularly palpable in cases such as ours, when participative models are on the move. These are extreme and explicit examples of technologizing democracy that make it particularly visible how delicate and often ambiguous democratization of science and technology is. We are not critical of RISCOM or other participative procedures per se. Rather, we have used the story of RISCOM travelling from Sweden to the Czech Republic to shed some light on the practice that, while building upon reasonable assumptions, often encourages too high expectations from, and unreflective handling of such political technologies.

Bogner's (2012) analysis of 'lab participation' is of particular interest here. In his conclusions,

Bogner asserts that "[w]hile society at large is becoming a laboratory in which knowledge is produced," in the form of "real-life experiments", "public participation is retreating from society into the lab", taking place in seclusion and on a small scale (Bogner, 2012: 522). This is a relevant insight, indicating deeply paradoxical developments in contemporary societies. The story of RISCOM reminds us, however, that the tension between the artificial world of laboratory and real-world conditions keeps its importance. RISCOM probably does make sense as a laboratory experiment with certain impact in the real-world politics, at least in theory. Secluded laboratory setting still allows effects that cannot be achieved in the wild, out-there. Artificial conditions remain productive, even for experiments in participation, provided we understand (and preserve) the distinction between them and the real life. It was this distinction which was lost in translating RISCOM from Sweden to the Czech Republic.

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Notes

1 The acronym RISCOM stands for 'Risk Communication' (Andersson et al., 1998: ii).

2 International socio-technical challenges for implementing geological disposal, INSOTEC (2011-2014) was supported within the EC 7th framework program (FP7-Fission-2010, 269906). We thank all the participants for fruitful discussions that helped us to shape arguments presented in this paper. We also thank to two anonymous reviewers for careful reading of our paper and useful feedback.

3 "To say something is to say it in other words. In other words, it is to translate… If a message is transported, then it is transformed. We never get a message that is simply spread" (Latour, 1988: 181).

4 One might be surprised seeing such a normative expression in an ANT-inspired study. But let us not be mistaken. ANT – with all its emphasis on symmetry and relationality – has never tried to suggest that it does not really matter what scientists (and other people) do in their efforts to 'discover truths'. Failure and success (e.g., good or bad science) have never been abolished words in this intellectual tradition. In his recent attempt to correct misunderstandings about his approach, Latour (2013: 159) insists: "there is a huge difference between making something well and making it badly".

5 Blaming RISCOM itself for being an inappropriate, badly devised model for public involvement, deemed to fail from the very beginning, would only be a mirror argument, similarly flat.

6 Such as in the ironic suggestion of a pneumatic parliament by Sloterdijk and Haegen (2003), by means of which the political culture of the West could easily and quickly spread all over the planet.

7 See Callon et al. (2009). For a recent discussion of the participatory turn in the field of radioactive waste management, see Bergmans et al. (2014).

8 See also Chilvers (2008), Kothari (2005), Sundqvist and Elam (2010) or Soneryd (2015) for discussion of how public involvement is becoming increasingly technical or even technocratic.

9 These principles were in 2005 described as being (VALDOC group, undated): a multi-perspective starting point; stretching capacity; impartiality and fairness and publicity.

10 For instance, who hosts meetings, where they take place, who moderates sessions, who writes the final report, and so on (Andersson and Wene, 2006).

11 Currently, there are ten active nuclear reactors in Sweden, which accounts for 40-50% of national electricity production (Daoud and Elam, 2012).

12 In this respect, RISCOM was introduced to the Czech Republic in a situation similar to the one in Sweden in the 1980s, i.e., characterized by a technocratic approach and local protests. See Carter (1988) for how the Czechoslovak government was committed to the nuclear energy program even before 1989, under socialist era.

13 In contrast to Sweden, in the Czech Republic the state assumes the responsibility for radioactive waste management, and therefore the state (not a company) is the implementer of geological disposal. The state organization called Radioactive Waste Repository Authority (RAWRA) was established in 1997, as a governmental organisation subordinate to the Ministry of Industry and Trade. See SURAO (undated).

14 The web sites related to RISCOM, i.e. online presentations of the two EC projects ARGONA and IPPA, as well as of Karita, a Swedish consulting company, which coordinated these projects, recently ceased to be available on the Internet – probably due to death of the RISCOM's main author and proponent. Former and incomplete versions of these presentations, however, are available via Wayback Machine at https://web.archive.org/.

15 The IPPA project aimed to take the results and experiences of the ARGONA project further, by means of implementing RISCOM in several East European countries, and establishing 'safe spaces' for public discussion within their national programs (cf. Andersson et al., 2011; see also IPPA, undated). The WG was explicitly associated with the IPPA project and it was taken by the IPPA participants as a RISCOM Reference Group.

16 Following De Laet (2000) we could say that the object of RISCOM became somewhat destabilized by the travel.

17 More specifically, the Ministry of Industry and Trade gave mandate to a state-owned mining company GEAM to apply for the site investigations, leaving RAWRA completely out for the moment.

18 In the beginning of 2015, the WG was officially changed into a working group of the Governmental Council for energy and raw materials strategy of the Czech Republic. However, already during 2016, mayors and NGO representatives started leaving the group and today the WG is "no longer existing" (quoted from the leaflet published by RAWRA in July 2017). But that is already another story, not directly related to the RISCOM era.

19 Our strategy was modified, we have to be more effective, writes the Director of RAWRA in a letter from June 3, 2013 to mayors of concerned municipalities.

20 During 2012-2013 RAWRA was repeatedly criticised in governmental documents. It even appeared on a list of useless institutions proposed for cancellation by the Government (Desítky bizarních úřadů zmizí, ušetří se tak miliardy [Dozens of bizarre offices disappear, saving billions], *Hospodářské noviny/iHned*, 15. 2. 2013. Available at http://archiv.ihned.cz/c1-59325600-desitky-bizarnich-uradu-zmizi-usetri-se-tak-miliardy).

21 In its Annual Report for the year 2012, the State Office for Nuclear Safety writes: "The entire program [of siting the repository, for which RAWRA is fully responsible] is quite inefficient in parts that we feel competent to comment." The Deputy Director of a company newly responsible for site investigations (against the will of concerned municipalities) says at a public meeting in Věžná, January 9, 2013: "RAWRA has the budget of some 170 or 200 million per year, 47 employees, and it has been operating here for twenty years. And the results? Zero, zero. Nothing".

22 Above all, RAWRA people were – pretty much in line with so called 'deficit model' (Wynne 2007) – too often mistaking 'informing the public' for public dialogue and participation in decision making. This is clear for instance in RAWRA's annual reports 2008-2013, which describe the relationship between RAWRA and the concerned public in terms of "communication", "public relations", "providing regular information on our activities and objectives", and so on.

23 Images from the Äspö laboratory or of the Swedish copper containers have been routinely used by RAWRA, for instance on its website, to promote deep geological repository as a viable and socially acceptable solution. During the public debates in the Czech Republic, one could often hear from the proponents of geological repository that in Sweden, people actually *wanted* the repository, and the communities were even competing for it.

24 In reality, as indicated earlier, the voluntary approach of SKB had no relation to dialogic exercises of RISCOM.

25 A telling detail: The English programme for the "IPPA End Users Conference" held in Prague in September 2013 mentions a slot entitled "Stretching of IPPA results by the end users". This is a clear hint by the foreign organizers to the idea that stretching should apply to all the participants of RISCOM - not only to the implementer of the repository (Andersson, 2009: 44), but in this case also to the implementer of RISCOM. The Czech version of the programme, however, puts the title of this very section quite differently and misleadingly – it says "*spreading* the IPPA results by their end users" (in Czech: "Rozšiřování výsledků projektu IPPA jejich koncovými uživateli"). This indicates that the Czech participants simply did not understand (and did not care about) the original meaning of the word at all. For them, it was an unintelligible marginal notion.

26 It is worth to note that this shift, although originally related to the RISCOM activities in the Czech Republic, does not concern this specific context only. 'Safe space' gains importance more generally. While browsing related web pages and IPPA project reports, RISCOM sometimes seems to have become practically equivalent to the notion of safe space.

27 It was unnoticed not only by the Czech participants, but even (deliberately or not, hard to tell) by the Swedish partners, the authors of RISCOM.

28 As clarified by the author of RISCOM himself, in his comments on an earlier output from the InSOTEC project: "[we] always emphasized that the model and the RISCOM process is for the clarification of stakeholder arguments for the sake of quality decision making and *not* for any purpose of consensus building leading to acceptance."

29 For an account of similar logic in explaining the success or failure in scientific experiments, see Collins (1985).

30 It has been argued that policy-related projects, even when framed by academic or research perspectives, tend to prefer success stories to failure stories to prove their relevance and meaningfulness (Epstein, 1990). Chilvers (2008: 3003) reminds that participatory practices nowadays have become a "vibrant and diverse industry" characteristic by rivalry between participatory experts engaged in intensive marketing of their own policy tools.

More than a Scientific Movement: Socio-Political Influences on Green Chemistry Research in the United States and France

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Abstract

The green chemistry (GC) concept originated in the United States during the 1990s to describe an approach to chemistry that aims to lower impacts on health and the environment. Based on 70 interviews with scientists from France and the United States, I investigated green chemists' practices and motivations, and the socio-political influences on their attitudes to GC. The results show that GC has a hybrid character, bringing together scientists with different motivations (funding, career, communication, ethical, political). The boundaries of the definition of GC are constantly shifting under the influence of research funding and environmental, industrial and agricultural policies. GC reflects the perfect adaptation of a terminology to the external conditions of chemistry's socio-political contexts. While this is a strength that gives GC the potential for changing overall practices in chemistry, this might also be its major weakness as it might completely lose its original environmental relevance, depending on the evolution of external drivers.

Keywords: chemical policy, green chemistry, scientific movement

Introduction: Theoretical foundations and research questions

Green chemistry (GC) is a concept that was coined in the United States during the 1990s, in an environmental policy context that displayed priorities shifting from waste treatment downstream towards pollution prevention at source. Since then, the term green chemistry has had increasing academic success, as confirmed by the number of publications using it (Linthorst, 2010). However, the nature of this keen interest from scientists remains unclear. Few explanations have been attempted in the social sciences, among which the most coherent was published by Woodhouse & Breyman (2005), who described it as a social movement. Other research[1] has acknowledged a wide variety of meanings given to the term GC, differing in their relative scientific versus political content (Schwarzman and Wilson, 2009; Wilson and Schwarzman, 2009a, 2009b; O'Brien et al. 2009; Iles, 2011) and in the research activities and knowledge areas included (Sjöstrom, 2006; Maxim, 2011a). Accounting for this diversity, Sjöstrom (2006) proposed two models for under-

standing GC: a classification model of different green chemistry activities (research activities, management activities and policy activities), and a second model concerning green chemistry policy and knowledge areas (green chemistry principles, industrial biotechnology and the "green sector,'' i.e., agriculture and forestry). The debate about what exactly constitutes research in GC spans a continuum from GC as a new scientific discipline within the field of chemistry (O'Brien et al., 2009), a science (O'Brien et al., 2009), a meta-discipline covering most of chemistry and chemical engineering (Sjöstrom, 2006), or a philosophical approach that underpins chemistry (Wilson and Schwarzman, 2009b; Llored, 2012; Bensaude-Vincent, 2013), to broader approaches including chemical risk policies (Iles, 2011) and all activities aiming at greening chemistry (Sjöstrom, 2006). The term itself seems to respond to a variety of research areas and objectives, which might explain its academic success, measured by the continuously increasing number of publications using it (Linthorst, 2010; Epicoco et al., 2012). Because of this heterogeneity, and not considering it a "rival to chemistry," Roberts (2005) expressed doubts about the "scientific" nature of the movement and underlined its discursive content.

However, these previous insights on GC have lacked empirical work aimed at understanding its spread and definition for "lay" green chemists, beyond the leaders' discourses. Analyses have mixed academia and industry, and researchers' motivations for using the term remain unknown.

While GC has previously been analyzed as a social movement (Woodhouse and Breyman, 2005), and as a scientific movement (Roberts, 2005), those analyses were based on historical institutional developments around the term and the actions of the field's "champions" (for example, founders Paul Anastas and John Warner), but did not look empirically at the research community in chemistry at large. Motivated by findings about its low level of adoption in the chemical industry (Matus, 2009; Wilson and Schwarzman, 2009a; Iles, 2011), existing empirical results in the social sciences are based on (a few) interviews with GC leaders from industry and academia as well as on multi-stakeholder workshops (Matus et al., 2007; Matus et al., 2010a; Matus et al., 2012), and propose a normative approach aimed at promoting GC. This literature focuses on identifying barriers (Matus et al., 2007; Matus et al., 2012), on policy measures (Matus, 2009, 2010; Matus et al., 2010a; Matus et al., 2010b; Scruggs et al., 2014) and on marketing tools (Iles, 2008) for the adoption of GC in firms.

Some empirical research has been done in France, with a recent analysis studying the national research funding program labeled "sustainable chemistry" and concluding that such targeted funding led to multiple research projects with various shades of green on a wide range of topics (Schultz, 2017). Others have looked at "institutional entrepreneurship," i.e., stakeholder activity aimed at creating or transforming institutions, in the context of the development of bio-based chemistry and the related industry in France (Nieddu et al., 2012).

Research question

However, the question: what is truly new in GC, as compared to usual research areas and practices in chemistry? has not yet been empirically dealt with, and the existing literature simply assumes that GC is "new" and "different" from business-as-usual chemistry.

In order to understand the novelty of GC (if any), I start here from its characterization as a social movement (Woodhouse and Breyman, 2005), which I deepen significantly, while using, however, the framework built by Frickel & Gross (2005) (see the Methods section). These authors proposed a general theory of scientific / intellectual movements (SIMs) to explain the mechanisms of change in the world of knowledge and ideas. Their theory insists on the socio-political conditions for SIM emergence and institutionalization, which I document on the basis of a historical and interview-based analysis of the socio-political forces driving GC.

I thus take an approach to "novelty" that goes beyond original scientific concepts and theories alone. Describing GC as a SIM allows me to analyze its novelty both in terms of scientific, conceptual developments and of the related socio-economic and political dynamics in which science and innovation are inevitably embedded. In other words, I test the hypothesis that GC is a new form of

existence of the science of chemistry in its socio-political and economic context. Analyzing novelty in GC thus comes down to focusing on both original theoretical developments and new relationships between research in chemistry and the socio-economic and political worlds.

The theoretical underpinnings of the Frickel and Gross's (2005) framework make their work particularly applicable to the green chemistry case study. First, they follow the "strong program" in the sociology of scientific knowledge, defending the idea that the truth of ideas must always be established and certified through social processes. Second, they acknowledge that scientific and intellectual fields are historically emergent phenomena, varying in time with respect to their internal social structure and academic practices. Third, they consider that SIMs are influenced by direct or indirect drivers emanating from the broader cultural and political environment. And fourth, they presuppose the measurability of phenomena associated to the emergence of SIMs. All these features of the SIM theory are extremely relevant for analysing green chemistry, for two reasons: 1) it is a scientific phenomenon having emerged as a result of socio-political forces (see the Results section), and 2) it cannot be understood - as will be shown below - without reference to the political rearrangements that it brings to the relationships inside the academic community, and between the science of chemistry and the ouside world (see the Discussion section and the definition of "political" given by Frickel and Gross, 2005: 207).

I employ empirical evidence from the scientific community in two countries – the United States and France – in order to understand how GC has changed the intellectual landscape in chemical research, and what have been the socio-political conditions of its development, including potential national specificities. I also take inspiration from the new political sociology of science (Frickel and Moore, 2005) as well as from previous work done by Woodhouse (2005), who compared GC with nanotechnology in terms of chemists' ability and responsibility in shaping their science. In particular, their analysis of the relationships between green chemistry, R&D policies and society inspired me in refining the methodological approach and in drafting the questionnaire.

A second objective of my work is to provide comparative insights, as few studies exist to help in understanding whether differences exist between countries concerning GC, and whether there is some national specificity. Matus (2009) provided a comparison between barriers to GC in the U.S., China and to some extent in India. The political background presumably influences the definition given to GC, in particular in a context of debates around policies on chemical risks (Wilson and Schwarzman, 2009a; O'Brien et al., 2009; Iles, 2011).

Methods

To respond to my research question, I build on two methodological instruments: the general theory of scientific / intellectual movements (SIM) developed by Frickel and Gross (2005), and interviews with 70 American and French researchers declaring work in GC.

Theoretical framework

The general theory of scientific / intellectual movements (SIM) developed by Frickel and Gross (2005) aimed at synthetizing work in the sociology of science, ideas and social movements, in order to explain how the world of knowledge and ideas changes. More precisely, after a definition of SIMs, and based on the assumption that they are similar to social movements, these authors sought to identify the social conditions under which SIMs "are most likely to emerge, gain adherents, win intellectual prestige, and ultimately acquire some level of institutional stability" (Frickel and Gross, 2005: 205).

SIMs are defined as "collective efforts to pursue research programs or projects for thought in the face of resistance from others in the scientific or intellectual community" (Frickel and Gross, 2005: 206). This definition is founded on several assumptions illustrated by numerous empirical cases from the natural and social sciences:

1. Having as a central goal the production and diffusion of ideas, SIMs have at their core a coherent program for scientific or intellectual change.

2. At the time of their emergence, SIMs promote intellectual practices that are contentious relative to dominant ways of approaching some problem or issue, within a given domain.
3. Because they significantly challenge past practices, SIM are inherently political, in the sense that they promote a redistribution of powers and social positions within or across intellectual fields.
4. SIMs are constituted through organized collective action, and require a certain spatial, temporal and social coordination. High-status intellectual networks are helping new ideas become influential, essentially by supporting publications, jobs for SIM participants, conference organization, grant support, and special issues of journals.
5. SIMs have a limited time span, between the announcement of a new intellectual program and either its institutionalization (subfield, discipline...) or its disappearance.
6. SIMs can vary in intellectual aim, ranging from topics previously undiscussed to new theoretical approaches to well-established terrains.

Based on these assumptions, four propositions lie at the core of the general theory proposed by Frickel and Gross (2005). These aim to provide theoretical, although pragmatic, guidance for future studies of SIMs. Each of these propositions is rooted in the sociological literature and illustrated by case studies. Given their centrality to the general theory and in order to avoid altering their meaning, I use them here in the original form proposed by their authors[2], while leaving discussion, in direct relation to the GC case study, for the next section (Results).

1. *A SIM is more likely to emerge when high-status intellectual actors harbor complaints against what they understand to be central intellectual tendencies of the day*. These actors hold higher scientific and social capital than their younger colleagues, which they can invest in a contentious intellectual / scientific proposal with less risk to their reputations.
2. *SIMs are more likely to be succesful when structural conditions provide access to key resources*. Among these resources, financial support and opportunities for publication are paramount. The intellectual opportunity structure can best be described by reference to three components: employment for SIM participants (essentially in academia), intellectual prestige (offered by the SIM to its participants), and organizational resources (university departments, and institutionalized channels of information flow such as scholarly organizations or informal personal networks).
3. *The greater a SIM's access to various micromobilization contexts, the more likely it is to be successful* (for example, conferences and symposia, research retreats, academic departments with graduate programs allowing the recruitment of students who may potentially become new members of the SIM).
4. *The success of a SIM is contingent upon the work done by movement participants to frame movement ideas in ways that resonate with the concerns of those who inhabit an intellectual field or fields*. SIM participants thus share an intellectual identity, which contributes to their motivation and gives them the feeling of belonging to a certain "type" of scientist or intellectual.

In pursuit of my research objective of highlighting the novelty brought by GC, I address each of the four propositions of Frickel & Gross (2005) in order to analyze the dynamics of GC emergence as a SIM. Depending on the proposition under analysis, my information sources are both various documents like books, articles or websites allowing historical insights into the processes of emergence and development of GC, (propositions 1 and 2), and interviews providing information that is not available in the literature (propositions 1 to 4). My respondents were 34 American and 36 French researchers declaring work in GC, interviewed between June 2013 and June 2014.

I focus exclusively on academia and leave aside developments of GC in industry, which would need specific methods and questioning (but I include interactions between researchers and industry that are relevant to my objective). My

methodological choices allow an exclusively qualitative analysis, and I have no ambition for quantification at the level of the whole green chemistry community.

Interviews

Interviewees were identified using several methods:

- literature search using the keywords "GC" and Google search using "GC" plus "research", "university" and/or "United States"
- search in the projects accepted for funding by the French National Research Agency (ANR), in the program *Chemistry and Processes for Sustainable Development*
- the snowball method (asking respondents to suggest other scientists working in the field of GC).

E-mails were sent to the researchers identified, and all those who agreed to contribute were interviewed. The questionnaire (Appendix 1) was structured in terms of nine themes: 1. Definition and identification of the field of green / sustainable / ecological chemistry; 2. Driving forces and constraints for GC; 3. Research practices; 4. Partnerships and research funding; 5. Institutional role of researchers; 6. Economy of green chemistry; 7. Health and environmental issues; 8. Green chemistry and society; 9. Scenarios of green chemistry. These were drafted by the present author, based on the existing literature on GC and her own previous research in the area, in order to grasp the changes in research practices brought about by GC, if any (theme 3) and to understand the socio-economic and political determinants of research activity in GC.

My American respondents worked either in colleges / small universities (nine interviewees) or in large universities (21), most of them public. A further two worked in public structures dedicated to GC policies, one worked in a company but had a significant background in academia, and one was in retirement but had previously worked in both academia and public structures dedicated to GC policy. All but one of my French respondents worked in academia, in either public universities or public research centers. The remaining respondent worked in industry, but had rich experience in academia. All but one of my respondents had at least several years of experience after their doctorate and a large majority held positions as researchers or assistant/full professors. The remaining one was a PhD student. Many of my American respondents worked in the chemistry department of their universities and all but one of my French respondents worked in chemistry labs.

The interviews were recorded and transcribed and I carried out a thematic qualitative analysis (Silverman, 2011). The analysis followed the themes of the questionnaire, which were then related to Frickel and Gross's (2005) propositions at the stage of writing the paper.

Results

Historical analysis

Before applying the framework developed by Frickel and Gross (2005) in order to describe the conditions for emergence as a SIM, the first question to be answered was whether GC has the features required for being characterized as a SIM at all. Historical analysis allows me answer this question, and to analyze the applicability of the first two propositions of Frickel and Gross (2005). However, the literature was insufficient for discussing the third and the fourth propositions, for this reason historical analysis has been used only for the first two propositions. For the remaining third and fourth propositions, interviews allowed to me acquire the information that was not available in the literature.

Can GC be characterized as a SIM? According to Frickel and Gross (2005), SIMs are "collective efforts to pursue research programs or projects for thought in the face of resistance from others in the scientific or intellectual community."

In light of the theoretical framework created by the GC founders and the existing STS / political sciences literature studying its emergence (Woodhouse and Breyman, 2005; Matus et al., 2007; Matus et al., 2010a; Linthorst, 2010; Iles, 2011; Matus et al., 2012), GC can be qualified as a collective movement (Frickel and Gross, 2005) within the chemistry community. Indeed, in the wake of the first EPA initiatives (see also the Discussion), the collective nature of GC has been built around multiple forms of institutionalization, and through

mutual feedback from both within and outside academia. Thus, the non-profit Green Chemistry Institute was created in 1997 as a partnership between the U.S. Environmental Protection Agency (EPA), the University of North Carolina and several companies. The Presidential GC Challenge Awards were created in 1995 to honor work in this field by industry, by the academic community, or by government. The emerging field took a new institutional step in 1999, when the journal *Green Chemistry* was created in the U.K. with the support of the Royal Society of Chemistry. Its impact factor (November 2017) is 9.125, which demonstrates its success in the chemistry community (the impact factor reflects the number of citations of articles published in a journal). Since 2006, the International Union of Pure and Applied Chemistry (IUPAC) has been organizing every two years an international conference on GC.

In France, the concept of GC became entrenched later, in 2007/08, but was succesful from the very beginning due to its major driving forces, namely the ANR funding program Chemistry and Processes for Sustainable Development and the CNRS program Chemistry for Sustainable Development.

Below, I analyze the emergence of the GC SIM in terms of the four propositions of Frickel and Gross, which allows me to scrutinize the novelty brought by GC as an intellectual stance and a scientific movement, and thus to respond to my research question.

Proposition 1: *A SIM is more likely to emerge when high-status intellectual actors harbor complaints against what they understand to be central intellectual tendencies of the day.*

For the U.S., GC fits well with this proposition, as the original aim of GC was revolutionary: to change the role of the chemist in the control of chemical risks and in environmental policy more broadly. Unlike Kuhnian processes of scientific revolution (Kuhn, 1962), the roots of change were external to the scientific world and came from policy. In a context of repeated controversies concerning chemical toxicity (Mazur, 1998) and facing the failure of what were labeled as "command and control policies" and a legitimacy crisis due to inefficiency in carrying out its legal mission to control chemical risks (Brickman et al., 1985), the EPA invested energy and resources[3] in a policy philosophy that displayed a shift of priorities away from waste treatment downstream, towards pollution prevention at source using more efficient technologies (Linthorst, 2010). The first such initiatives had emerged in states affected by controversies about chemical waste, such as the Toxic Use Reduction Act (TURA) in Massachusetts in 1989. The new approach spread at the federal level with the 1990 adoption by the U.S. Congress of the Pollution Prevention Act (PPA). Later, several states introduced GC policies, such as the Michigan GC Program in 2006, the California GC Initiative in 2006-2008 (Iles, 2011), and regulations relating to chemical risk in Washington, Maine, Minnesota, Oregon, and Vermont (Duvall et al., 2016).

Given the political purposes and the enrollment program intended by its proponents, criticizing the chemistry community was not a discursive priority, although it subtly underpinned the original manifestos. The concept started to be used by chemists whose institutional positions provided ex-ante legitimacy, such as Kenneth Hancock, former director of the Chemistry Division of the U.S. National Science Foundation (NSF). Declaring that "Whether you are talking about oil spills, or landfills, or ozone holes... or any [human-made] environmental problem that has ever occurred, it comes from chemistry" (Amato, 1993: 1538), Hancock then framed these problems as opportunities for chemists: "Any solution that you will devise will come from chemistry. (Amato, 1993: 1538)"

A year later, EPA employees Paul Anastas and Carol Farris (1994) briefly mentioned the term GC in the introduction to their book, referring to "benign by design" chemistry. But the main features of the paradigm shift were already present, starting with the first chapter by Anastas, which highlighted the new role of the chemist. While synthetic chemists do not traditionally consider themselves as actors capable of influencing environmental impacts, benign by design (later called "green") chemistry placed them at the heart of pollution prevention. Hence, this would significantly alter the work of chemists, who have been concerned historically with two criteria: the functions that substances may usefully accom-

plish, and the cost of industrial production of said substances. In benign by design chemistry, a third criterion had to be accounted for during the molecular design phase, namely impacts on human health and the environment.

The spread of the term has been further reinforced by the success of Anastas and Warner's book (1998: 11), defining GC through 12 principles[4] with a pragmatic connotation, which have become the internationally recognized GC brand. The book insisted on the second revolutionary novelty brought by GC, its focus on the intrinsic properties of substances for control of their health and environmental impacts, instead of on risks (i.e., the relationship between exposure and intrinsic toxicity). This new approach gave scientists the power to influence pollution, while previous regulations aimed at reducing risks had placed this power solely in the hands of industry and regulators.

Thirdly, what was also new was the privileged relationship envisaged between chemistry and toxicology. With the help of toxicology, chemists could get to know the molecular characteristics responsible for the dangerous properties of substances, and thus become able to avoid these in the structures of new molecules. It thus became important to educate chemists about toxicology, a discipline previously completely absent from their curricula.

In France, in contrast to the government leadership that initiated GC in the U.S., the use of the term in was promoted through academic channels. But for this country dissatisfaction also came not from within chemical sciences, but from outside, namely from the concern of scientists for the public image of their science. In France, the "negative image of chemistry" has been an increasing concern for many years and remains an open wound for many chemists (Maxim, 2011b). If some have adopted defensive attitudes, essentially contesting the public's ability to understand their research, ANR and CNRS funding programs have been using these concerns as opportunities, in line with their American counterparts who reacted to a political framework unable to relevantly deal with chemical risks. The crisis leading to GC was not within chemistry, but outside it: while chemists have always pleaded that they work for human well-being (given the role of chemistry in agriculture, pharmacy, industry…), environmental concerns were significantly weakening this discourse about the legitimacy of chemistry as a socially relevant science.

The movement was initiated in France by well-established chemists. This also fits with the proposition of Frickel and Gross concernig SIMs. In the early 2000s, the National Institute for Agricultural Research (INRA) was the first body in France to bet on the success of GC, by investing in related research. In order to take full advantage of its specialized human resources in agricultural sciences, historically encouraged after the first oil shock of 1973-1974, INRA redefined the term GC as synonymous with bio-based chemistry. Thus, from its origins GC in France did not share the U.S. focus on reducing toxicity, but was directly linked to the country's agricultural potential and to the political context of the moment in the European Union.

The first French reference book to use GC in its title was coordinated by an INRA-based scientist (Colonna, 2005), at that time head of the department for "Characterization and elaboration of products issuing from agriculture" and currently Professor at the prestigious Collège de France. The first paragraph stated: "The choice of this book titled GC reflects the problem: what are the best uses for renewable carbon?" (Colonna, 2005: IX). The authors made no reference to the American terminology, the twelve principles, or the founding works.

In parallel, the largest fundamental research institution in the country, the CNRS, began to use the term, following the lead of chemist Isabelle Rico-Lattes. In 2006 she created the research program "Chemistry for Sustainable Development" (Chimie pour le Développement Durable, CPDD), which explicitly built on the 12 principles and had the objective of networking scientists to boost the emergence of a new research field. At the time, Isabelle Rico-Lattes was already a well-established and recognized researcher (CNRS Silver Medal in 2006, a high distinction for researchers in France, then Chevalier de la Légion d'honneur in 2008), with political responsibilities as officer on environmental health for the Ministry of Environment (2004-2006).

With CNRS including a significant number of researchers on ecology (whereas toxicology was essentially based in other research institutes), the CPDD programme promoted interdisciplinary collaboration between chemistry and ecology (Maxim, 2011a; Rico-Lattes and Maxim, 2014). The network included about 900 researchers in different universities and research institutions in France, and four working groups on: renewable resources; new synthesis pathways including biotechnologies; improving synthesis processes, and assessing/reducing the impact of chemistry on the environment. Thus, they enlarged the semantic boundaries of the term GC beyond the only "renewable carbon" definition in 2005.

Also in parallel, a new regulatory framework was developing in Europe. The White Paper on a new chemicals strategy for the European Union (2001) contained the main elements of a regulation to be known as REACH (Registration, Evaluation, and Authorization of CHemicals), covering all chemicals produced or imported in volumes larger than 1 t/year, as well as replacing over 40 existing directives and regulations. Guided by the precautionary principle, REACH was adopted in 2006 and aimed at improving knowledge of the properties and uses of individual chemical substances, all by encouraging the substitution of the most dangerous chemicals on the market. In France, a working group including ANR and some research institutions issued a report on the relationships between REACH and research in chemistry (De Guillebon et al., 2009). This work contributed to the inclusion of REACH in ANR calls for projects in sustainable chemistry.

Proposition 2: *SIMs are more likely to be successful when structural conditions provide access to key resources.*

In the U.S., following Kenneth Hancock's commitment in 1992, the NSF funded a call for research projects on Environmentally Benign Chemical Synthesis and Processing ($ 950,000), and then a partnership between the NSF and the EPA, which led to a common call for such projects in 1993. The NSF further promoted GC in the early 1990s through its Industry / University Cooperative Research Centers Program (Anastas and Farris, 1994). Also, the Department of Energy reserved a part of its Environmentally Conscious Manufacturing Program for environmentally friendly chemistry.

Later, a proposal for a specific funding mechanism, the GC Research and Development Act, was proposed to and rejected by the U.S. Congress three times. Finally, an amendment was introduced to the America Competes Reauthorization Act (signed into law by President Obama in January 2011) to fund GC projects through the NSF.

The spread of the term GC in France was top-down, driven by research funding policy that explicitly linked chemistry and sustainable development. In the CPDD programme, funding was relatively modest and dedicated to networking through seminars, conferences, and interdisciplinary PhDs. From 2007 to 2013, the ANR programs labeled "Chemistry and Processes for Sustainable Development" (2007-2010) then "Sustainable Chemistry – Innovation – Industry" (2011-2013) represented the main national funding source for French chemists and reached about 9 million euros / year (Schultz, 2017).

Funding sources in France are more numerous than in the U.S. At a national level, the main funders of GC research are the ANR and the Environment and Energy Management Agency (ADEME). The Government also funds applied research through the Unique Interministerial Fund (FUI) mechanism. Specific national or regional funding mechanisms have been created in France, such as the Institutes of Excellence for Decarbonated Energy (IEED), the Institute for Plant Chemistry, Picardy, Innovation in Plant, Education, Research and Technology (PIVERT) and the French Institute for Agro-based Materials (IFMAS). Some regions, such as Poitou-Charentes, have also had their own research funding programs. Additionally, funding from the European Commission can be important.

Among the structures encouraging collaboration between public research and industry, competitiveness clusters bring together companies, research laboratories and training institutions, by geographical area and specific topic.

Another effective mechanism in France is the CIFRE PhD program, which funds doctoral students who must undertake part of their activi-

ties in a public research laboratory and another part in a company.

In the following, the results of interviews are again organized by proposition from Frickel and Gross's (2005) theoretical framework. Whereas historical analysis was relevant to discussing the first two propositions but insufficient to address the third and the fourth, interviews provided me with the additional information needed to complete that discussion and to analyse the last two propositions.

Results from interviews

Proposition 1: *A SIM is more likely to emerge when high-status intellectual actors harbor complaints against what they understand to be central intellectual tendencies of the day.*

According to Frickel and Gross (2005), a SIM most often stems from dissatisfaction with dominant intellectual practices in a field. The major trigger for scientific movements is doubt, which can be occasioned by multiple factors: anomalous research findings questioning the generally agreed "truth" of the discipline, but also changes in the structure of research personnel inducing changes in the values embedded in research, theoretical developments in other scientific domains or unexpected discoveries. The success of a SIM will be conditional upon its promotion by high-status intellectual actors who occupy prestigious positions and for whom professional risk is lower if they diverge from mainstream research pathways. Usually these actors are older individuals and their younger protégés.

In the historical analysis-based discussion of Proposition 1, I have looked at the role of GC founders (high-status intellectuals) in promoting criticism of the "central tendencies of the day" in conventional chemistry. Here, I further address the positions of "regular" chemists towards the business-as-usual paradigms of their discipline regarding health and environmental concerns. For a SIM to emerge, it needs collective work, and to be spread over a part of the scientific community. In order to understand those who make up this collective unit forming a SIM, and their distinctive features as compared to their colleagues, I asked my respondents whether GC opened new avenues of research and what novelties this term had brought to their work.

In the U.S., my respondents worked in areas some of which already existed before the term GC spread through the chemistry community: catalysis and biocatalysis, alternative solvents (ionic liquids, supercritical fluids, water), the chemistry of biofuels, or bio-based chemistry. For many, the term GC shed new light on work that was already being done, albeit with more attention now being paid to environmental issues: "But, in my view, the twelve principles are more like a cover for what, in the 1990s, were existing things." While the term was not yet in use, specialists in catalysis had already been pursuing GC "unknowingly." For a scientist engaged in research on supercritical fluids, "We were taking advantage of the environmental benefits of supercritical fluids before anybody had coined the term GC."

For those who say that GC has changed the way they work, the main change concerns the choice of research topics, for example, deciding to engage in polymer chemistry for the first time, or undertaking a new project on energy storage.

Yet the concept of GC has not created a new field of research and green chemists come from very different thematic areas in chemistry. The only new field of research mentioned was targeted molecular design for creating "benign by design" substances, brought up in the 1990s in the founding literature. But, despite its originality, my respondents mentioned this subject only rarely.

Like their American colleagues, French respondents reported a wide range of research topics. They all had a long history in chemistry that preceded the term GC in areas such as: catalysis and electrochemistry in soft chemistry conditions, chemical catalysis (homogeneous, heterogeneous, asymmetric, organometallic), biocatalysis, bio-based chemistry, supercritical fluids, synthesis of organic polymers including bio-based, with particular applications in the field of energy.

As in the U.S., GC was not a new field of research in France, except for developing less toxic solvents to meet REACH requirements and new algorithms to better implement the environmental factor (E-factor).

As for the definition of GC, American chemists routinely referred to the 12 principles, a

cohesive element in an otherwise heterogenous community. The definitions of GC are diverse. For example, a substance might be termed "sustainable" because it could be extracted from nature (for example, ethyl lactate derived from corn). The sustainable character was even more important when the raw resource was usually treated as waste (for example, orange peel or rice husks). Ionic liquids and supercritical fluids were "green" because they can replace toxic organic solvents. In the case of bio-based materials, biodegradation in certain conditions was an interesting property that made chemistry "greener." Some nanoparticles were "green" because they reduced the amount of biocides released into nature during the treatment of trees.

Thus, "green" was not a characteristic that defined a field of research (for example, catalysis) or a particular research topic — it was always contextual. The very use of the term GC seemed to be specific to each chemist and to the corresponding context: "It depends on the audience." For another chemist, the "green" was virtually impossible to verify, because the environmental impact criteria for a substance or a process could be diverse, numerous and sometimes contradictory; a process might be considered "green" by some chemists and "not green" by others. Further, for some, chemistry was green not only if environment and health impacts were less, but also if it lowered costs: "My definition of green chemistry is something that has superior performance, has superior cost benefits and, all by the way, has an environmental benefit."

It was the toxicity issue that seemed the most difficult to integrate. The interviewees gave several examples of work described as GC that they recognized, however, as double-edged regarding toxicity concerns. For example, ionic liquids could replace toxic organic solvents, but some of these were also toxic. Nanoparticles fitted within the field of GC for some respondents (for example, because they were used as catalysts to produce bio-fuels), but others raised the question of their potential toxicity. While GC was born of the idea that all chemists should be trained in toxicology, most respondents said that they ignored it, were not trained in this discipline, and some considered it a separate scientific field beyond the realm of chemists.

Like their American colleagues, French chemists defined "green" in a manner that was context specific: "Finally, no theme will be purely green. The boundaries are quite fluctuating." "We must also accept that we can move GC forward a little bit in lots of directions, and it will not always be 100% green (...) but everything that improves things — replacing a solvent, doing something less toxic, using less natural resources — in the end is always a win."

As for American researchers, the meanings of the term were varied. For a researcher "working on catalysis, one immediately respects one of the twelve principles of GC." But, arguing that GC was not only about that single principle, this researcher highlighted other elements: the use of agricultural resources, the use of aqueous solvents, work on making conditions of pressure and temperature as low as possible. For another, GC could be just "a simpler chemistry," i.e., one that avoided additional molecules as far as possible. Chemistry was green if it was bio-based: "Rule number 7 should be, I do not remember the exact formula, but it was about using biological carbon, so renewable carbon." "Fischer Tropsch is going to be considered as a green chemistry in the sense that if we start from the biomass which is a renewable source which is decarbonated, we can consider that it is rather a green Fischer Tropsch." But, again, the respondents insisted on respecting more than one of the 12 principles.

But, as in the U.S., GC was often losing here a key element of its original definition, namely the idea of limiting substances' intrinsic toxicity and using predictive toxicology to obtain benign by design substances. Some viewed this as an impossible goal because the impacts of chemicals were considered to be not only a function of their intrinsic properties, but "also the dose, the quantity, the time... so it's extremely complicated." Chemists thought, overwhelmingly, that toxicity issues were not part of their job: "There are people specialized in it, who will watch this stuff." For these French chemists, toxicity needed to be studied only after the development of a substance or method, by toxicologists, and usually in a

regulatory context. For this reason, the study of toxicity would be an additional constraint, often expensive and irrelevant to research.

As with American green chemists, the treatment of toxicity was the weakest point in French GC, although chemists stated a priori that this was an important aspect: "We are also working on nano catalysts, nanoparticles etc. and we must admit that, for the moment, we do not ask ourselves much about the toxicity of these compounds."

As for teaching, one toxicology course in a Master's program was mentioned. When lessons on environmental and health impacts of chemicals were included (three cases), such topics as life cycle analysis and the regulation of chemical risks were addressed.

Proposition 2: *SIMs are more likely to be successful when structural conditions provide access to key resources (employment for SIM participants, intellectual prestige, organizational resources)***.**
According to Frickel & Gross (2005), opportunities for gaining access to resources are vital to SIM emergence, as much at individual, local level (university, laboratory) as at a wider, collective level (funding programs, opportunities for publication, employment for SIM participants, intellectual prestige, organizational resources such as university departments or institutionalized channels of information flow).

Research funding

For the American interviewees, funding played a critical role in the direction they took in their work. Funding, often public, facilitated entering the field of GC. The main source of U.S. funding is the NSF, but some respondents thought that this institution lacked clear criteria for what was "green," which remained at the reviewers's discretion. For this reason "It hadn't really shifted the money…" Funding from the EPA had favored GC since the late 1990s, yet its financial resources had since been reduced significantly. Also, the U.S. government Departments of Energy, Agriculture and Defense were considered useful sources. Finally, respondents mentioned the ACS "round tables" mechanism supporting topics related to the specific needs of companies and providing scholarships for students, or the Petroleum Research Fund. However, few projects could be financed, and with relatively low amounts. Other sources cited as marginal supporters of the field included the Toxics Use Reduction Institute (TURI) at the University of Massachusetts Lowell, the Dreyfus Foundation, some states including Michigan, the United Soybean Board's fund, the student competition of the EPA titled People, Prosperity and Planet, and private donors.

Regarding industry funding for academic research, the essential criterion for collaborations remained the desired functionality; "greening" tended to be a side effect of initiatives by academic researchers, instead of at the explicit request of a manufacturer. Generally, the American respondents reported little or no industry funding for GC; the average ratio of private to public funding for research varied from 0 to 30% of total funding per researcher from private industry and foundations, versus 70 to 100% public funding. In two cases, the ratio was 50:50, but those funds were not targeted solely at research in GC, but rather to all the activities of my respondents.

As in the U.S., in France, overall, "it helps a lot to find funding". Unlike their American colleagues, almost all of the researchers surveyed had industrial GC collaborations, with the ANR strongly encouraging industrial partnerships, and specific financial incentives giving tax benefits to firms investing in R&D.

Of the total budget of my French respondents' teams working in GC, direct industrial funding on contract covered 5 to 50% (mean 28%). This was their operating budget, which excluded permanent salaries (publicly funded in France) but included salaries of temporary staff such as trainees, PhD students and postdocs.

Local organizational resources

American respondents said they were integrating GC into larger classes (for example, organic chemistry), although actual changes made to the courses taught remained unclear.

The term GC seems to have gained a legitimate place in academic language, so that the hierarchical status of the research taking this approach was usually favorable or neutral, with wide range of positions represented:

1. The hierarchy of universities, including chemistry departments, had seized a funding opportunity to make space for teaching and research in GC. In one case, institutional investment in GC could not have existed without support from the Dean of the Chemistry Faculty. In other cases, GC was a strategic investment area like any other, but was subject to explicit support: "The hierarchy of the university is concerned with economic development, and green is a product of that."
2. The hierarchy itself provided opportunities for GC, creating specific courses labeled as such. This reaction was partly a move in the competition with other universities and aimed at attracting students, whose favorable attitude to GC seemed clear. GC was included in the university's brand image, which was a useful strategy for small private universities. By contrast, in some already well known and competitive universities, "we have not tried to do that (GC) here, in part because we have a sufficient number of students (...) I like to say that we already did a good job for them, and we have other more urgent problems."
3. GC was part of a communication strategy around the greening of the university campus, coinciding with a range of environmental criteria such as energy saving and responsible waste management. Hierarchies were not providing additional institutional support by, for example, creating positions or adapting curricula.
4. The hierarchy was indifferent to GC, an attitude that seemed to be predominant in the universities of my interviewees. When professors proposed to "green" their chemistry classes, they were able to do this, but without obtaining specific financial or institutional resources. GC was in some cases a question of reducing students' exposure and costs related to equipment, reagents or waste treatment from chemistry laboratories dedicated to practical work. This cost-benefit thinking often happened in particular circumstances, for example during the renovation of laboratory buildings. Costs were reduced by modifying the experiments proposed, which could then be characterized as greening.

   For universities where research played an important role, the conventional metrics of research were priorities for the hierarchy and above any other considerations: "Publish and get funded, that's the pressure, whatever the field." When the hierarchy of universities, and in particular chemistry departments, were opposed to GC, it was because they associated it with a critical attitude to industry practices or because of ideological disagreement.

In France, while they were not enthusiastic to the point of investing significant resources, hierarchies were often not opposed to GC either: "For the lab, what matters is metrics, metrics... good publications and a maximum of contracts." But such criteria also motivated some researchers: "What is important is the impact factor, and quoting indices, so we are lucky that GC is at this moment on a roll, so GC articles are well cited."

When hierarchies were favorable to GC, this was due to its research, funding and partnerships potential: "It was well received. (…) It was called GC, but behind this we put the science that goes with it… then we can label it GC, or sustainable chemistry, in order to get funded. But behind this we must put scientific principles…. and when the science was there, it has always turned out well."

The teaching of GC has targeted essentially Master's and PhD students and only in rare cases the lower level. While some courses or Master's programs were specifically labeled with the term GC, the associated concepts were usually included in more general courses.

There has been no tendency to undertake green practical work in France, and U.S. initiatives on the topic are unknown. Moreover, toxicology, and environmental science more generally, are almost absent from teaching provided to chemists.

Contextual organisational opportunities and resources for GC

In the U.S**.**, the direct effect of chemical risk policies on chemists' work in GC is insignificant. Environmental regulations are usually not a parameter of chemists' thinking when choosing topics or working methods. However, high-media-profile controversies have impacted chemists (plastic

bags, brominated flame retardants, endocrine disruptors...), giving them hints about the nature of the problems to solve.

One could assume that regulation would be a pressure on manufacturers, who would then be encouraged to innovate and to fund public research on GC. However, this was not the case in my sample, as researchers were not receiving demands from industry explicitely driven by greening or regulatory objectives.

Unlike American chemists, French chemists knew of the existence of REACH and talked spontaneously about it. Yet this was a very superficial knowledge. The respondents understood that substances had to pass the regulatory filter, but did not know what this filter was, and what properties substances should or should not have. As a consequence, the respondents did not consider REACH as a reality they should be integrating into their research: "We do not feel really concerned, because REACH affects rather the commercial level and people selling products, while we… we are doing research, we are far upstream of REACH in fact."

Proposition 3: *The greater a SIM's access to various micromobilization contexts, the more likely it is to be successful***.**

According to Frickel & Gross (2005), academic departments play the prime role in the emergence of a SIM, in particular through the access they provide to students and to the recruitment of new young members, and through their capacity to deliver degrees.

The role of university departments as micromobilization contexts

My results indicate that in the U.S. university departments were usually not places of micromobilization. Many of my respondents were a minority or even isolated, rather atypical individuals in their universities: "I try to bring GC into the department, but it is difficult to sell."

Some universities nevertheless had a tradition of promoting GC and made institutional investments: the University of California at Berkeley, the University of Oregon, to some degree Yale University, and the University of Massachusetts. But globally, it was rare for chemists displaying their work in GC to be part of chemistry departments where a majority of their colleagues showed the same orientation.

The presence of GC in my respondents' universities was often associated with the existence of a department or program in environmental science. While in some cases the green chemists had a dual attachment to the two departments, in other cases collaborative research or teaching took place between the two disciplines, or courses in GC were provided to students pursuing a degree in environmental science. Yet collaboration was not systematic.

Unlike by American respondents, in France GC is viewed as a trend that all chemists should adopt, more or less: "Everyone wants to do so because they have an awareness or because it helps sell their work… there is a bit of both, I think." "Yes, I do not know if this is opportunism, but many people hastened to go down this route. But it was very, very much welcomed by the community." The concept has further spread through the creation, in several laboratories, of teams with common GC objectives and research strategies. An important difference from the U.S. was that respondents in France were part of whole teams working on GC, the smallest being of between three and ten people with permanent and non-permanent positions, and the largest bringing together dozens of people.

I was not able to observe a systematic correlation between the presence of chemical laboratories that display research in GC and laboratories in environmental science that are geographically close or present in the same research institution or university. Geographical or institutional proximity does not particularly favor such collaboration.

Other micromobilization contexts

In the U.S., conferences played an essential role in GC socialization. One respondent, for example, met Paul Anastas and John Warner at a conference: "I was immediately converted. I understood what it was and, all of a sudden, I realized that ... wow! It was exactly what I wanted to do! That day, my career swung." Also, Anastas and Warner's (1998) book was cited routinely as a gateway to the world of GC, as an obvious "must" and sometimes as a revelation, a discovery.

The role of organized networks was important in spreading the concept. On issues related to teaching GC, for example, the University of Oregon organized training programs each year for teachers in chemistry from other American universities. To encourage networking, a map provided the names and details of various professionals who asked to register (available at: http://greenchem.uoregon.edu/).

Concerning the spread from the U.S. to France, for one of my respondents, who was among the first to use the term in the latter country, the trigger for adopting the concept was meeting Paul Anastas at a conference. Another heard the term at a conference in the 2000s. Publications were an important source of terminology transfer, but also contacts with the industry and the national ANR funding program.

Proposition 4: *The success of a SIM is contingent upon the work done by movement participants to frame the movement in a way that resonates with the concerns of those who inhabit an intellectual field or fields.*

Frickel & Gross (2005) consider social values and broader world views as lively roots for SIM, which are "ultimately sustained by ideas." SIM participants frame their movement through books, articles, grant applications, conference proposals, which all form their "intellectual identity." Unlike the first three propositions, this one reveals the specificity of GC, because, as a general pattern, I could not identify particular motivations which would render it different from any other research topic or thematic area. Besides their common use of the term, most green chemists do not seem to share a common intellectual identity that would differentiate them from the rest of the chemistry world. Some exceptions remain, of individuals being strongly motivated by environmental commitments.

What motivates chemists to use the term GC?

The major motivation for using or not using the term, for both U.S. and French researchers, is the strategic management of their teaching and research topics, of funding and of their image and credibility as researchers. Funding is a very significant, but not the only, reason why U.S. respondents chose the field. GC sets challenging new questions and opens up new research paths, and therefore represents an intellectual motivation and presages career opportunities: "A lot of the older, complex problems... there are too many people in the field, and it is hard to break into, this is an opportunity… you could start at the ground level and… it's kind of the beauty of new ideas coming out, and people trying to wrestle with those."

The ability to attract good students to internships and doctoral studies is an important motivation for university professors involved in postgraduate programs. Greening may allow universities to reduce operating costs by reducing expenses for waste treatment and for facilities like fume hoods, while limiting students' exposure to toxic substances.

Finally, for a small minority in my sample[5], GC was above all about strong personal beliefs and ethical engagement, and these researchers have, if this was needed, pushed the limits of the academic system.

Similarly, some of the French respondents were aware of the term GC early on, in the mid-1990s, but did not adopt it immediately: "At the beginning I did not want to use the term GC. I was considering that it had an ideological connotation, and I think this complicated things, it did not help."

Chemists adopted GC "without knowing", so using the term was merely a strategic positioning issue, "at the whim of tenders" or of the requirements of international publications. But GC was equally a scientific challenge: "There is so much to discover in there... (...) This is a fantastic new exploration field." For those who refused to label their work as GC, the term had a negative connotation because it was "overused": "people put everything and anything inside it."

Is GC involving a change in the views of chemists about their own responsibility as regards the potential health and environmental impacts of their work?[6]

The great philosophical change promoted by GC — in the conception of its founders — concerned the role of chemists in the chain of responsibility linking laboratory, industry, users and policy-mak-

ers. Unlike other techno-sciences, the founders of GC claimed for their science a new social awareness: as chemists invent substances and processes in their laboratories that will eventually impact health and the environment, they also have the power to mitigate pollution. But, besides the field's "champions", do "regular" chemists agree with this new social role of their research?

For U.S. respondents there was no simple answer to this question, because the definition of green was blurry, given the complexity of potential health and environmental impacts of chemicals and the impossibility of measuring these absolutely. Furthermore, chemists' cannot control the uses of the knowledge they produce:

> if I'm making a chemical, and I publish and then I'm reponsible for, you know, to bring it to lab… But then, the issue is if I do publish it because, whatever it's a non-interesting reason, and someone finds a different negative use for it, and we find out later that, you know, there is a mistake (…) how guilty I am? Of bringing this to the world, that is a question that I don't have a good answer for.

The principle of lowering the intrinsic toxicity of substances was questioned, based on the idea that exposure was the primary cause of risk, and the chemist had no control over the use of substances. Faced with the question of moral responsibility, chemists often returned to a more traditional philosophy of techno-science and the criterion of use outweighed the reference to intrinsic properties specific to GC:

> I think it's stretching it too far, because the similar thing would be someone doing, nuclear physics should think about the bomb possibilities every time they think, which is too far. I mean you know, that's part of your consideration but it can't be the dominant one.

Those in my sample who promoted the "benign by design" proposals of the field's founders were also professionally close to them.

Like their American counterparts, French respondents essentially thought they had limited power to influence the potential health and environmental impacts of their work. Little control was associated with their work, which was only a part of the final product or process. The responsibility for these impacts thus lay mainly with industry employees who made production decisions. The toxicity of substances was viewed as a function of exposure, making the user mainly responsible for the impacts:

> Now, the (problem of) endocrine disruptors, it stems from excessive consumption ... just take the case of Doliprane (n.a.: paracetamol), for example, I think there are problems of rejection of Doliprane in wastewater, because it has more and more people who consume this drug. Is this the fault of the pharmaceutical industry? Is it the fault of the chemist who developed this product or is it the fault of consumers who use the drug in an extremely unthinking way?

Pursuing an objective of minimizing the possible impacts was also dependent on each specific research situation. A good idea that leads to solving a theoretical problem could be based on "brown" chemistry, which could later be improved: "If it is to understand a mechanism, if it is to understand an interaction or things like that, one should not start by saying that there is a trick, it's dangerous, there will be waste."

Discussion and conclusions

Based on historical analysis and a sample of 70 interviews with green chemists in France and the U.S., my objective was to understand what is new in GC as compared with conventional chemistry, investigating the characterization of GC as a SIM (Frickel and Gross, 2005). The analysis of the emergence of and present developments in GC showed that three of Frickel and Gross's propositions fit well, while the fourth proposition underlines the specificity of GC as compared with other SIMs. Regarding its theoretical content, the novelty of GC lies essentially in a different mobilisation of existing research having an environmental potential (biobased chemistry, catalysis) but is not as radical as intended in its original, critical formulations (green molecular design).

In particular, my results show that GC has a hybrid character, bringing together scientists with different, sometimes nested, motivations (funding, career and publication opportunities, communi-

cational, ethical and political motivations). Most of these motivations could characterize more generally any academic activity, independently of greening objectives. My respondents used different definitions of the term and adapted its use to the specific context and public. This is not necessarily in contradiction with other SIMs, as Frickel and Gross (2005, 206) noted: "This is not to say that all participants in a SIM will agree as to the meaning of its ideational or knowledge core." Nevertheless, for GC, the diversity of meanings is particularly high. The definition of GC is proteiform, multiple and changing. The term has been continuously redefined by chemists; it took on additional meanings as more researchers working on new subjects came to consider their work as part of this field. It was built, and is still being rebuilt, by permanently passing from one space of legitimacy to another (research proposals for funding, journals and conferences, policymakers, non-specialist public). Its boundaries are constantly shifting and its meanings differ not only from one person to another, but also from one context to another, and from one audience to another, including for the same chemist. The 12 principles play a symbolic role of unique historic reference, but, with their ultimate flexibility, they adapt to every field of chemistry. Therefore, some do not adopt the term because they perceive it as disadvantageous to their image. In short, the term plays a strategic role, which does not exclude ethical underpinnings, but whose main function is political and interactional. It allows a restructuring of the research community in chemistry, reorganizing the balance of powers on certain topics, reinventing some of its rules, and expressing its position relative to the outer world - especially that part of the outside world that challenges its legitimacy due to controversies over risks, jeopardizing the community's social position and respectability.

In short, GC is essentially defined in response to external influences from research funding and from the framing of environmental, industrial or agricultural policies. The comparison between the U.S. and France is illustrative of this influence of policy. In the U.S., the meaning was influenced from the beginning by the context of the PPA, with central emphasis on toxic waste management. In France, the term was shaped by chemists' perception of the negative public image of their science, and by policies that governed agriculture, research funding, and industrial practices.

These initial political drivers make of GC an original case of a research community fully created by external forces originating in the non-scientific arena. Paul Anastas himself is a particular case, by comparison with other SIM founders, since his age and academic status at the first moments of GC were not his major assets. His resources were political legitimacy (EPA), his charisma, his discursive and working capacity. On the other hand, the role of well-established scientists in a SIM is confirmed for France.

Roberts (2005) also proposed an analysis using Frickel and Gross's (2005) general theory, as I did, but expressed doubts about the characterization of GC as a scientific movement, among other factors because he did not consider it a rival to chemistry. However, my large empirical basis, which was not available to Roberts, and my comparison between two historical national pathways of GC, allowed me to produce a more nuanced analysis of the "dissatisfaction" driving the movement, and of the role of academic leaders (important in France, as compared with the U.S.). Furthermore, I argued that GC had truly proposed a revolution in chemical thinking (the Results section). However, more than ten years later, I arrived at similar conclusions about the heterogenous and partly discursive nature of GC.

The comparison between the two countries is rich in insights. First, about the relative roles of government in the emergence of a SIM: whereas in the two countries the movement began as a top-down impulse, in the U.S. the push came originally from the EPA, whereas in France the major role was played by the national funding agency, as well as by the top-level hierarchies of the two largest research centers in the country, CNRS and INRA.

Secondly, the American interviewees referred to greening practical work for students in chemistry and to including toxicology in their curricula, yet these ideas had no resonance in France. French respondents mentioned no American source other than "the 12 principles," so I infer that the original sources of GC were not much read in

France, and that the concept was rebuilt and propagated through French channels, taking on a national connotation.

The two countries show the same striking difficulty in integrating concerns for toxicology into the teaching of chemistry, research practices and the mentality of chemists. While this was the original impulse of GC, the SIM developed and grew without it, losing its main original feature on the way. This difference persists, with recent literature in the U.S. acknowledging the "chemistry – toxicology gap" and encouraging green chemists to move towards green molecular design (Zimmerman et al., 2014; Anastas and Zimmerman, 2016), while this is absent in France.

In conclusion, GC is an example of perfect adaptation of a terminology to the external conditions and socio-political contexts of chemistry. While this is a strength that gives GC an important potential for changing overall practices in chemistry in the direction of better inclusion of health and environmental concerns, this might also be its major weakness as it might die or completely lose its original environmental relevance, depending on the evolution of external drivers.

1. In line with the methodological approach taken in this paper, this overview of the literature focuses on the social sciences and excludes the numerous definitional papers published by chemists, who are themselves the subject of study.
2. I restrict myself here to a minimalistic presentation of the four propositions, which are extensively discussed and demonstrated in the original article, in order to allow enough space for communicating results directly related to the GC case study. Furthermore, I come back to the particularities of each of these propositions during their exemplification on the GC case study.
3. The Office of Pollution Prevention and Toxics (OPPT) was created in 1988.
4. A good source for the 12 principles is the website of the American Chemical Society : https://www.acs.org/content/acs/en/greenchemistry/what-is-green-chemistry/principles/12-principles-of-green-chemistry.html
5. This might not be the case in the whole GC community, as my sample is not statistically representative. Feedback from the respondents does confirm my findings, showing that strong environmental commitment characterizes a minority of green chemists, but a statistical confirmation of this finding should involve quantitative research insuring the representativeness of researchers declaring work in GC.
6. The question of chemists' moral responsability in relation with green chemistry has been extensively addressed in Maxim (2017).

Acknowledgments

This work was supported by the Interdisciplinarity Mission of the National Center for Scientific Research (CNRS), France. I am grateful to Kara Lefevre and Jean Morris for stylistic and linguistic improvements.

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Appendix 1

RESEARCH

Definition and identification of the field of green / sustainable / ecological chemistry

1. Personal presentation:
   - Current position
   - Past positions
   - Training
   - Past and current research topics

2. How did you start working on green chemistry?

3. As regards the relationship between chemistry and sustainable development (including health, environment, social and economic issues, etc.), do you prefer talking about:
   - sustainable chemistry
   - green chemistry
   - chemistry for sustainable development
   - ecological chemistry
   - any of these terms ; a proposal ?

4. How do you define ***"green" (or other term)*** chemistry? Could you please provide key words defining:
   - your work in ***green*** chemistry
   - ***green*** chemistry in general

5. Which are, in your opinion, the priority research domains in ***green*** chemistry?

6. How do you measure the "green" character of your activities? Do you use a specific metrics?

7. When did you heard for the first time the term green chemistry? Do you remember in which context?

8. Is green chemistry:
   - innovation for substitution (replacing existing substances by other substances having a lower risk)
   - breakthrough innovation (changing not only substances but also uses, industrial practices, economic model, etc.) ; e.g., nanotechnologies, GMOs, synthetic biology, etc.

Driving forces and constraints

9. In your opinion, which are the driving forces for green chemistry? (e.g., policies, internal dynamics of research in chemistry, funding, industrial demand, etc.)

10. Which are the barriers for the emergence of green chemistry? (e.g., funding, forming new researchers, regulation, markets…)

11. Is green chemistry currently (enough) taught in universities? (if no) Why?

12. Are toxicology / environmental sciences taught in classes for chemists today? (If NO) Why?

13. Which are the jobs chosen by your students after they finish their education?

14. Is the hierarchy of your lab encouraging research in green chemistry?

Research practices

15. In your research practices, work on green chemistry has changed significantly your working practices? Or these changes are in line with your previous work?

16. In your team, working on green chemistry involves collaborations with other disciplines, with which you were not used to work before?

17. Do you work with toxicologists? With ecotoxicologists? With ecologists? With agronomists? With researchers in social sciences?

18. How do you know if the substances you use are toxic or not? Do you use specific databases, your own knowledge, or other sources?

19. Are there many of your team / lab colleagues working in green chemistry?

20. Is there an Environment department or an Agriculture department in your university / research center? Is it big? Do you work with?

21. In your opinion, which is the attitude of most chemists in your country as regards green chemistry ?
    - very favorable, green chemistry is a major challenge for chemists
    - favorable, but one cannot be sure yet that green chemistry has a future
    - Green chemistry is a transient fashion
    - Green chemistry is a continuation of currently existing practices (chemists have always tried to reduce the impact of their activity on health and the environment)
    - Others

    Do you consider yourself as being part of a minority?

Partnerships and research funding

22. Green chemistry has allowed you and your team to obtain new research funding? Funding that you wouldn't have had without this green approach?

23. Have you already developed partnerships with the industry on green chemistry? If yes, which kind? (e.g., common laboratory, contract, project). How do you perceive these collaborations?

24. Which are the other sources of research funding for your activity on green chemistry?

25. Which is the proportion between funding by industry and other sources, on green chemistry?

26. You and your team are members of particular research and innovation clusters or organizations related to green chemistry? Which is their role on the direction taken by your work?

27. Did you benefit of help from public structures aiming at facilitating the transfer of research in the industry?

Institutional role of researchers

28. Do you have responsibilities in research management or at the interface between research and policy or private arena? For example in Scientific Boards, policy, expert or other advisory activities, in research funding organisms, in reviewing research projects, in companies…?

29. Are you editor of a journal?

Economy of green chemistry

30. Which are the perspectives for applying in practice your research in green chemistry?

31. Do you protect your research with patents? If yes, how many did you develop on green chemistry subjects?

32. Have you already been concerned by a commercially successful application of your research by the industry? (if yes) what do you think about this experience?

33. Have you already been involved, with or without industry partner, in a start-up or similar structures?

Health and environmental issues

34. In your opinion, concern for risks can be included in the design of chemicals since the very beginning step of synthesis (benign by design) ? If yes how? (feasibility). Do you think chemists should act on intrinsic properties (hazards).

35. In your opinion, researchers in chemistry have a responsibility as regards the risks of the substances they develop?

Green chemistry and society

36. What do you think about criticism from civil society (NGOs) on chemical risks?

37. Do you think that NGOs and the public should, and can, get involved in orientations given to research and innovation in chemistry?

38. (if yes) at which level?

39. Research funding agencies

40. Directly at the level of research projects or laboratories, even common research with researchers?

41. At the level of research applications, via public consultations and NGO involvement in the work of safety agencies?

42. Which are the opportunities for publicizing the green character of your activities? (patents labeled "green chemistry", publication in specialized journals, communications for the general public, interactions with journalists, books, etc.)

Scenarios of green chemistry

43. How do you imagine green chemistry in 2030, as scientific discipline, and as technique present in society and economy? For example, evolution of: research? relations between research and industry? the industry? consumers? Policies?

Could you please communicate me other names of researchers working in green chemistry?

Making Nature Investable: from Legibility to Leverageability in Fabricating 'Nature' as 'Natural Capital'

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Abstract

In response to perceived valuation problems giving rise to global environmental crisis, 'nature' is being qualified, quantified and materialised as the new external(ised) 'Nature-whole' of 'natural capital'. This paper problematises the increasing legibility, through numbering and (ac)counting practices, of natural capital as an apparently exterior 'matter of fact' that can be leveraged financially. Interconnected policy and technical texts, combined with observation as an academic participant in recent international environmental policy meetings, form the basis for a delineation of four connected and intensifying dimensions of articulation in fabricating 'nature' as 'natural capital': discursive, numerical-economic, material and institutional. Performative economic sociology approaches are drawn on to clarify the numbering and calculative practices making and performing indicators of nature health and harm as formally economic. These institutionalised fabrications are interpreted as attempts to enrol previously uncosted 'standing natures' in the forward-driving movement of capital.

Keywords: nature, natural capital, accounting

fab ri cate
1. To make; create.
2. To construct by combining or assembling diverse, typically standardized parts …
3. To concoct in order to deceive[1]

Introducing the fact(ish) of 'natural capital'

In 1973 economist E.F. Schumacher published *Small is Beautiful: Economics as if People Mattered*. In this text, Schumacher argued for a downsizing of economic production, such that the (re)productive life of the 'irreplaceable capital' of nature – which he termed 'natural capital' – would remain abundant (Schumacher, 1973: 4; also Boulding, 1966). Schumacher argued that instead modern economies were committing the grave error of consuming their capital, leading to its use at an alarming and even 'suicidal' rate. He attributed this error to a lack of recognition of the "capital provided by nature and not by man", because "[m]odern man does not experience himself as a part of nature but as an outside force destined to dominate and conquer it" (Schumacher, 1973: 3–4).

Fast forwards four decades to November 2013, and we arrive at the inaugural World Forum on Natural Capital[2], held in Edinburgh amidst a technological and global context that would have

been unrecognisable to Schumacher writing in 1973. Established with the support of an assemblage of now powerful international organisations – including the United Nations Environment Programme (UNEP), the International Union for the Conservation of Nature (IUCN), and the CEO-led network of corporations that is the World Business Council for Sustainable Development (WBCSD) – the Forum website claimed that "a revolution is taking place in how businesses and governments account for natural capital"[3]. In its intention to be "a focal point for business leaders and others to explore the full implications of this rapidly evolving issue [i.e. how to factor natural capital values into business practice]", and "with the aim of turning the debate into practical action", the Forum captured the attention of major international corporations and financial institutions. An invite- or application-only CEO's club offered high-level networking over drinks and breakfast for the Forum's most senior delegates. This club was sponsored by Alliance Trust Plc., a self-managed investment company whose top invested companies include oil companies such as Royal Dutch Shell, BP, and Gulf Keystone Petroleum, financial institutions such as Lloyds' Banking Group and HSBC Holdings, and construction companies such as Barrett Development Plc.

This inaugural World Forum on Natural Capital was held against a background of concern regarding global environmental degradation and the roles of corporate and financial investment in contributing to this. The emphasis, however, was far from approaches to downsize economic activity, as urged by Schumacher in the 1970s. Instead, the focus was on how corporate and financial worlds might account for environmental costs and assets so as to both maintain and enhance profits and competitive advantage within this context of global environmental concern.

The World Forum on Natural Capital, repeated in November 2015 and returning in November 2017, exists alongside a number of initiatives designated with the noun 'natural capital' to indicate a fact in the world that requires increasingly little explanation. The Natural Capital Committee[4], for example, is charged with advising the UK government on "the sustainable use of England's natural capital" and advocates a target of incorporating natural capital losses and gains into national GDP (Gross Domestic Product) accounts by 2020. The Natural Capital Declaration[5] prepared for the UN Rio+20 'Earth Summit'[6] commits the financial sector to voluntarily mainstream "natural capital considerations" into all financial products and services. The global Natural Capital Protocol encourages inter-organisational alignment to create a world where business both enhances and conserves natural capital[7]. The Natural Capital Financing Facility[8] is a financial instrument of the European Investment Bank (EIB) and the European Commission aiming "to prove to the market and to potential investors the attractiveness of biodiversity and climate adaptation operations in order to promote sustainable investments from the private sector". All these initiatives approach 'natural capital' as an apparently exterior, measurable and (ac)countable matter of fact, sharing definitions along the lines of the Forum that "Natural Capital can be defined as the world's stocks of natural assets which include geology, soil, air, water and all living things" from which "humans derive a wide range of services, often called ecosystem services, which make human life possible".[9]

These multiple utterances and institutional convergences notwithstanding, 'natural capital' does not exist in any *a priori* sense. It is a new 'Nature-whole' (Asdal, 2008) being conjured into being through particular practices of conceiving, framing, measuring, numbering and calculating the so-called natural world (see Spash and Clayton, 1997; Sullivan, 2013a, 2014; Coffey, 2016; Nadal, 2016). This new nature-whole is being made both legible (i.e. 'readable', cf. Scott, 1998) and leverageable (i.e. able to be advantageously leveraged as an asset), even as 'Nature' is simultaneously being conceptually disassembled in many disciplinary engagements. Indeed, the analytical-empirical encouragements of Actor-Network-Theory and Science and Technology Studies (STS) (e.g. Latour, 2004; 2007), combined with acknowledgement of contemporary 'Anthropocenic' forcing of the biophysical by the socioeconomic (Crutzen and Stoermer, 2000), are both acting to reduce a 'naturalist' (cf. Descola, 2013) emphasis on an external nature distinct from human endeavour. In doing so, world-making participations combining the social with the natural are (re-)energised, both

conceptually and materially (cf. Deleuze and Guattari, 1987[1980]). The outcomes of such participations, however, are as disparate as the values with which they are infused. Consider, for example, the relational, egalitarian and deeply participatory ontologies described and theorised for Khoe and Sān actors in southern Africa (see Biesele, 1996; Marshall, 2006; Sullivan and Low, 2014) in contrast with the Promethean techno-science participations proposed for humans as the 'God species' (Lynas, 2012) in the *Ecomodernist Manifesto* (Asafu-Adjaye et al., 2015).

In this paper, I explore a range of social dimensions leading to the consolidation of the noun and 'Nature-whole' of 'natural capital'. I follow a growing number of studies concerned with 'how nature is enacted' through bringing 'nature into account/ing', such that 'the enactments of nature and the enactments of economy go together' (Asdal, 2008: 125, 123). Asdal (2008), for example, studies the technical inscription of critical limits or thresholds that enabled nature to be taken into account in the context of managing atmospheric acid rain pollution loads in Europe. Lohmann (2009, 2014) details the making of marketable carbon emissions reductions, setting this fabrication in a historical context of pollution trading, cost-benefit methodologies and performative equations. Lippert (2014) documents how carbon data entities are created, enrolled and stabilised by corporate environmental managers so as to link carbon sustainability practices with broader agencies in sustainability and carbon accounting. Verran (2013: 36) assesses how through numbering practices a "very particular nature" is brought into being, one that "humanity can do business with" (also Scott, 1998; Robertson, 2006; Sullivan, 2009, 2013b; Pawliczek and Sullivan, 2011; Dempsey, 2015; Carver and Sullivan, 2017).

These analyses suggest that the practices now fabricating nature-as-natural-capital can also be documented empirically and subjected to critical assessment regarding their world-making implications. In the current paper, and following a performative economic sociology approach that asks *how* previously external(ized) dimensions of social and ecological life become formally calculated as economic (Mennicken and Miller, 2012: 18), I aim to draw attention to the discourses, technologies and practices through which the object of 'natural capital' is created. I am guided by a core research question, namely: how is nature-as-natural-capital becoming legible as an increasingly fetishised 'object' (or set of objects) in the world, charged technically (through numbering and calculative practices) and socially (through institutionalised expert agreement) with authoritative, objective power?

This core question is complemented by a secondary question regarding how nature as the objectified fact(s) of 'natural capital' is becoming financially materialized, i.e. leveraged, as such. I invoke 'materiality' here in the sense used in accounting and auditing to indicate the importance or significance of a financial amount or transaction (see, for example, *UNEP FI, 2010*).

The paper is structured as follows. After a section on method and interpretive framework, I identify and trace a series of connected 'dimensions of articulation' (also see Wilshusen and MacDonald, 2017) through which 'nature' is being progressively qualified and quantified – i.e. fabricated metaphorically and materially – as 'natural capital'. I close with a brief conclusion noting the propensity for natural capital thinking to affirm the conditions of continuity for capital(ism).

Method and interpretive framework

As noted above, the metaphorical noun and category of 'natural capital' is taking hold in productively interesting ways that can be documented and diagnosed empirically. The observations and reflections on which this analysis is based derive from two main sources of data. The first is review of a range of recent and interconnected grey literature policy documents. Whilst not subjected to a formal textual analysis (although see Sullivan and Hannis, 2015), these texts were read closely and were selected because they frequently refer to each other and are representative of a broader constitutive move towards the natural capital accounting practices considered in this paper. These researched grey literature texts are signaled below with italics in the in-text references (for example, *WBCSD, ERM, IUCN, PwC, 2011*). The acronyms of authoring organisations, which are themselves illustrative of the assemblage of actors and institutions articulating around 'natural capital',

are detailed in full in the bibliographic listings for these documents.

My second source of data derives from 'observant participation' and 'event ethnography' (Brosius and Campbell, 2010; MacDonald and Corson, 2012; Dempsey, 2015) conducted between November 2011 and May 2016 as a participant and occasional speaker at fourteen events concerned with 'green economy' policy solutions to losses of 'natural capital and biodiversity'. As noted in Table 1, a number (n=5) of these events were closed meetings intended to inform national and international policy, some designated as 'high-level' policy dialogues. Others (n=6) were open beyond-academia workshops, conferences and seminars regarding strategies for the management of nature-as-natural-capital. The remainder (n=3) were social movement 'counter-forums' and campaigns-organising meetings. Participation in these events and subsequent communications has enabled direct observation and discussion regarding the orchestrated uptake of, and struggles over, 'natural-capital-thinking' in these contexts (cf. Macdonald, 2013), as well as facilitating access to many of the grey literature texts drawn on below. Following Bracking (2015) I thus utilise these ethnographic events, field-notes made during and in reflecting on these events, and associated document stores as 'keyholes' or windows through which to see wider characteristics of emergent natural capital materialisation and governance. Although my role as an academic researcher was clear at these events, with the exception of the direct quote opening 'Dimension 3' below, I observe confidentiality and anonymity by not identifying or quoting participants directly.

In analysing and interpreting these two sources of material, and in response to my core research question (as stated above), I utilise two key approaches:

1. an STS emphasis on the social fabrication of entities treated as positioned in the world so as to engender socio-economic effects (Latour, 2010);
2. an economic sociology focus on economization, i.e. the framing, numbering and performative dimensions that enact both people and entities as formally economic (Çalişkan and Callon, 2009, 2010).

As the following analysis makes clear, I am drawn in particular to:

1. social fabrications, including numbering practices, that *enact* (cf. Mol 2002) and fetishise 'natural capital' as an apparently exterior 'matter of fact' or 'factish' (after Latour, 2010) that inspires actions in the world with identifiable effects;
2. the design and application of numbering and calculative practices and devices so as to "render technical" (Murray Li, 2007a, b) and perform entities as formally economic (after Mackenzie and Millo, 2003; Callon and Muniesa, 2005; Callon, 2006; MacKenzie et al., 2007; Çalişkan and Callon, 2009, 2010); and
3. practices of 'articulation' in both senses of the word, i.e. as speech act utterances that shape discursive reality as understood amongst those participating in relevant speech communities (Austin, 1962), and as acts of 'joining' and connection between people, organisations and practices associated with the qualification, quantification and materialisation of nature-as-natural-capital (MacDonald and Corson, 2012; Corson et al., 2013; MacDonald, 2013; Wilshusen and MacDonald, 2017).

Following Foucault (2008[1979]), I consider these overlapping practices to combine to consolidate a neoliberal governmentality in environmental governance (as discussed in Sullivan, 2006, 2013b; Murray Li 2007a; Fletcher, 2010; also Mennicken and Miller, 2012). The conduct of multiple actors, organisations and policies is thereby oriented towards the truth regime of the market (Foucault 2008[1979]) such that environmental health and harm become governed through market-based instruments applied to social and ecological parameters that are overwhelmingly economized. In alignment with other studies of economization processes (see Table 2) this analysis is structured into three overlapping and currently consolidating 'dimensions of articulation', namely:

1. *discursive* – the systematic metaphorical 'authorising knowledge' (Murray Li, 2007a, 2007b) of 'external nature' in economic and financial terms, amongst which 'natural capital' and 'ecosystem services' are paramount;
2. *calculative and accounting* – the numerical and technical inscription of delineated nature aspects as capital assets, such that these can

be added to and offset against other forms of accounted capital and in economic models more generally; and

3. a nascent *materialisation* of these inscriptions, through which nature-as-natural-capital is able to be leveraged in financially material terms.

Each of these shaping dimensions of articulation is *traversed by* a fourth dimension:

4. the consolidating and co-functioning *institutional* articulations effecting joinings between individuals and organisations so as to fabricate natural-capital-relevant institutional and governing assemblages. These assemblages can be thought of as 'dispositifs' (Foucault, 1980: 194) and 'agencements' (Deleuze and Guattari, 1987[1980]) that shape, reproduce and amplify the articulations forming the basis for the next three sections of the paper (also see MacDonald and Corson, 2012; Wilshusen 2014; Wilshusen and MacDonald, 2017).

Table 1. Non-academic policy-oriented events, participation in which by the author informs the present analysis.

Event and website (listed in chronological order)	Location & Date	Open/ closed	Author's role
1. High-level policy workshop on *Markets for Biodiversity and Ecosystem Services: Challenges and Opportunities* https://www.chathamhouse.org/events/view/179829	Chatham House, London, UK 11/2011	Closed	Invited opening speaker
2. High-level UN Convention on Biological Diversity (CBD) 'Dialogue Seminar' on *Biodiversity and Finance* http://www.dialogueseminars.net/quito/summary/summary/executive_summary.html	Quito, Ecuador 03/2012	Closed	Invited 'expert participant'
3. 7th Trondheim Conference on Biodiversity (organised by the Secretariat of the UN CBD, the United Nations Environment Program (UNEP) and the Norwegian government) entitled *Ecology and Economy for a Sustainable Society* http://www.naturoppsyn.no/tk7	Trondheim, Norway 05/2013	Closed	Invited speaker on plenary panel
4. *Ecosystems Offsetting and Trading* workshop (organized by NGOs FERN and re:Common)	Brussels, Belgium 10/2013	Closed	Invited speaker
5. *Inaugural World Forum on Natural Capital* http://naturalcapitalforum.com/2013highlights/	Edinburgh, UK 11/2013	Open	Non-corporate delegate
6. Protests associated with the *Counter-Forum on Natural Commons*, held to coincide with #5 above http://www.counter-balance.org/forum-on-natural-commons-nature-is-not-for-sale/	Edinburgh, UK 11/2013	Open	Participant
7. *To No Net Loss of Biodiversity and Beyond* policy conference organised by Forest Trends, the Business and Biodiversity Offsets Programme (BBOP) and the UK Department for Environment, Food and Rural Affairs (DEFRA) http://bbop.forest-trends.org/events/no-net-loss/	London, UK 06/2014	Open	Participant
8. *Challenging Biodiversity Offsetting and the Financialisation of Nature* counter-forum, held to coincide with #7 above http://www.fern.org/publications/presentations/nature-not-sale	London, UK 06/2014	Open	Invited panel chair
9. *Naturally Speaking Public Dialogue on the National Ecosystem Assessment* organized by Valuing Nature Network, DEFRA, NERC, Sciencewise, University of Exeter http://valuing-nature.net/naturally-speaking	Royal Society, London, UK 10/2014	Closed	Invited 'expert speaker'
10. *Payments for Ecosystem Services (PES) Workshop* for policymakers, practitioners and PES scholars http://www3.imperial.ac.uk/newsandeventspggrp/imperialcollege/lifesciences/grandchallengesinecosystemsandtheenvironment/eventssummary/event_9-4-2015-14-45-14	Imperial College, London, UK 04/2015	Closed	Invited plenary speaker
11. *Second World Forum on Natural Capital* http://naturalcapitalforum.com/ nb. unable to attend, but stayed in touch with event	Edinburgh, UK 11/2015	Open	Invited plenary speaker

Table 1 cont.

12. *The Future for Policy on Biodiversity and Natural Capital in the UK: Priorities, Practicalities and Targets* – Westminster Energy, Environment & Transport Forum Keynote Seminar http://www.westminsterforumprojects.co.uk/forums/agenda/natural-capital-2016-agenda.pdf	London, UK 04/16	By application	Participant plus co-author of article in final seminar transcript
13. *Accelerating Green Bonds Uptake* http://www.sustainableinvestmentforum.org/knowledge-centre/webinars/accelerating-green-bond-uptake-webinar	Webinar 05/2016	By application	Participant / listener
14. *Earthwatch Debate - Does Nature Come With a Price Tag?* http://eu.earthwatch.org/events/2016/02/09/earthwatch-debate-does-nature-come-with-a-price-tag-	London, UK 05/2016	Open	One of six invited debate speakers

Table 2. Correspondences between a series of tripartite distinctions in social studies of created numerical objects that come to count.

Source	Distinction 1	Distinction 2	Distinction 3
Present paper 'dimensions of articulation'	qualification #1 discursive	quantification #2 technical-numerical (numbering, accounting & calculative practices)	materialisation #3 material
	legibility		leverageability
	traversed by #4, institutional alignments and practices of assemblage		
Miller and Rose, 1990; Rose and Miller, 1992. Influenced by Foucault on governmentality, discussed by Mennicken and Miller, (2012: 16)	rationalities (political principles to which government should be directed)	technologies (mechanisms and instruments through which political rationalities and government programmes are made operable)	programmes of government (designs that configure specific relations and locales)
Hacking (1992) studying conjoining modes of representation and of intervening in laboratory science (discussed in Miller and O'Leary, 2007: 707)	ideas theories	things instruments	marks inscriptions
Hornborg (2016: 62) discussing dimensions of money	idea	sign (i.e. unit of account)	potent material force

I proceed with review of the accelerating discursive and institutional changes translating 'nature' into 'natural capital'.

Dimension 1: Discursive equations of 'nature' and 'capital' – two institutional histories of metaphorical translation

Metaphorical thinking is intrinsic to human conceptual, creative and communicative life (Lakoff and Johnson, 2003[1980]). 'Natural capital' is a potent metaphorical device asserting that one multiplicitous category, namely 'nature', can be known through invoking another multiplicitous category, namely 'capital' (as reviewed in Spash and Clayton, 1997; Cooper 2000; Åkerman, 2005; Read and Scott Cato, 2014; Sullivan, 2013a, 2014; Coffey, 2016; Nadal, 2016).[10] As noted above, the metaphorical connection between 'nature' and 'capital' has a long pedigree. Its ascendancy in formal and popular parlance has intensified in recent years, however, such that in many contexts the term 'natural capital' has come to mean what previously would have been denoted by the terms 'nature' or 'the natural environment'. Here I draw attention to two parallel and connected social histories of the metaphor to illustrate the contingent nature of shifts in thought and practice associated with its use (cf. Murray Li, 2007b: 274).

'Natural capital' in environmental and ecological economics

Conceptualising 'nature' as 'natural capital' has been a significant, even foundational, move in environmental and ecological economics over the last three decades. Intensified usage of the term tends to be attributed to the late David Pearce (as, for example, in Foster and Gough's 2005 volume on *Learning, Natural Capital and Sustainable Development*, also review in Åkerman, 2005). Pearce was an influential environmental economist and UK government advisor who wrote several defining environmental economics texts (for example, Pearce et al., 1989; Pearce, 1993, 1998; Pearce and Moran, 1994). In 1988, Pearce stated that "[s]ustainable development is categorised by economic change subject to 'constancy of natural capital stock'" (Pearce, 1988: 598), such that, and as Åkerman (2005: 35) describes, "natural environments are thought of as a stock of natural assets serving economic functions". In the then emerging discipline of *ecological* economics, this notion of 'natural capital' as a stock of value-generating assets was also confirmed in statements such as:

> what natural capital and manufactured capital have in common is that they both conform to the working definition of capital as a stock (collection, aggregate) of something that produces a flow (a periodic yield) of valuable goods or services (Prugh et al., 1999: 49).

This 'stock of natural capital' is increasingly conceived as all of 'external nature': the beyond-human natures constituting 'the environment' that in conventional economic models have tended to be treated as 'externalities', i.e. as non-costed resources whose use may become overuse causing degradation (cf. Hornborg, 2016: 62). In Daily et al.'s (2011: 3) introduction to *Natural Capital: The Theory and Practice of Mapping Ecosystem Services*, "living natural capital" thus encompasses "Earth's lands and waters and their biodiversity" and provides the "ecosystem services" that flow from these. The UK's Natural Capital Committee (NCC), established in 2013, uses a similar definition, namely:

> [n]atural capital refers to the elements of nature that produce value or benefits to people (directly and indirectly), such as the stock of forests, rivers, land, minerals and oceans, as well as the natural processes and functions that underpin their operation (*Natural Capital Committee, 2013*: 10).

'Nature' as 'natural capital' is thus framed in environmental and ecological economics and associated policy (con)texts as physical *stocks* of 'nature', both renewable (i.e. living) and nonrenewable (i.e. 'fixed', as in stocks of mineral wealth), that produce 'natural resources' as definable 'goods', 'services' and 'values'.

As argued by Åkerman (2005: 37, 39), however, the polysemic metaphor of nature-as-natural-capital, whilst metaphorically strong and heuristically powerful, is analytically weak. This enables the metaphor to perform different work for different groups of people in diverse contexts, a disparate mobilisation that permits the metaphor to act in the world with varying effects. Indeed, in its inauguration in both environmental and ecological economics the metaphor already

meant contrary things, and was used for varied ends and with diverse outcomes (as summarised in Table 3 in Sullivan, 2014: 12). Åkerman (2005: 36) states that in environmental economics "the accountant's view of nature" was underlined through an emphasis on "natural capital" as value-generating "environmental assets" with varying degrees of substitutability. In ecological economics, on the other hand, "ecosystem processes and ecological knowledge" informed by "the ecosystem modeller's view of nature" provided the underlying focus, and the possibility of substitutabilities between the material natures on which these models were based was resisted (Åkerman 2005: 36; also Wackernagel and Rees, 1997; see discussion in Hannis, 2015: 24–28).

This complexity notwithstanding, popular environmental literature and media are increasingly embracing and publicizing versions of the metaphor (see, for example, Daily and Ellison, 2002; Juniper, 2013). Noticeable in this popularisation is an association and elision between 'natural capital', 'finance capital' and accounting. Former Friends of the Earth director Tony Juniper (2013: 268), in *What Has Nature Ever Done for Us? How Money Really Does Grow on Trees*, thus states that "[t]he ecosystems that naturally renew themselves, and which supply us with the huge range of commercially valuable services and benefits, are sometimes seen as analogous to financial capital, and are increasingly referred to as 'natural capital'". In his foreword to Juniper's text, HRH The Prince of Wales refers to "what is known in the jargon as 'natural capital' … a set of economic assets which … can produce dividends that flow from these assets indefinitely" (in Juniper, 2013: xi).

In these statements, then, the metaphorical functioning of 'natural capital' is working to extend both an environmental economics preference for calculative practices of accounting for nature, and an elision between 'natural' and 'financial' spheres of capital. As discussed below, a normalising conception of 'nature' as a dividend-generating capital asset is coming further into focus through initiatives that seek to account for this asset and financially materialise its 'dividends'. This diversely legible and leverageable 'natural capital' has arguably been boosted through a parallel history of the metaphor that conceives of 'nature' more systematically as 'a bank of natural capital' from which ecosystem services flow as 'dividends'. It is to this history that I now turn.

'Nature' as a 'Bank of Natural Capital Assets'

Alongside the increasing legibility of nature-as-natural-capital asserted in environmental and ecological economics is a parallel vision of nature more literally as a bank of financial assets. Two global moments stand out in the creation and consolidation of this vision. The first is associated with the leadership of the WBCSD, established at the first United Nations (UN) Earth Summit in Rio de Janeiro in 1992. This CEO-led network was initiated by millionaire Maurice Strong, formerly an entrepreneur in the Alberta oil patch and president of the Power Corporation of Canada, in his capacity as Secretary General for the 1992 Earth Summit (and previously for the 1972 UN Stockholm Conference on the Human Environment). One of the first key assertions of nature as akin to a financial bank account can be traced to this powerful player in global environmental governance. In various speeches in the early to mid-1990s[11], Strong asserts repeatedly that: "[i]n addressing the challenge of achieving global sustainability, we must apply the basic principles of business. This means running "Earth Incorporated" with a depreciation, amortization and maintenance account" (also discussed in Sullivan, 2010, 2013b).

This sentiment has become almost a truism in environmental governance. It has been used, for example, as a marketing hook by private sector organisations such as the US-based Environmental Consultancy Agency[12] and formerly by the global investment fund Eko Assets Management (discussed in Sullivan, 2010) – now 'Encourage Capital'[13], and is echoed directly by former UNEP official Don de Silva (2008). More recently, Caroline Spelman, as Environment Minister for the *UK's Conservative coalition government*, launched DEFRA's (2011) Natural Environment White Paper *The Natural Choice: Securing the Value of Nature* by stating that: "… if we withdraw something from Mother Nature's Bank, we've got to put something back to ensure that the environment has a healthy balance and a secure future".[14] The UK's Prince of Wales, similarly asserts that "[t]he ultimate bank on

which we all depend, the bank of natural capital, is in the red" *(HRH Prince of Wales, 2013:* online; also quoted in *van Herwijnen, 2016:* 2). This metaphor of nature as 'a bank of natural capital' is presented in rather literal form by the United Nations and European Union TEEB (The Economics of Ecosystems and Biodiversity) project, through its *Bank of Natural Capital* website[15] in which nature's stocks and flows are depicted such that they accord with the format of a standard online current bank account.

'Capital' is plural

These two brief historical tracings of the term 'natural capital' indicate that whilst the metaphor qualifies thinking about 'the natural world' in terms of capital, the ways the metaphor does this are multifaceted. This is because 'capital', like 'nature', is incommensurably plural, even when restricting consideration of capital to physical and economic capital only.[16] Capital exists variously as:

i. heterogeneous and not fully commensurable or substitutable physical factors of production (including goods such as machinery, as well as land-as-property as a fixed capital asset) that on balance sheets also constitute liabilities with maintenance costs;
ii. the medium (i.e. money) through which factors of production may be valued, bought and sold and thus fabricated as interchangeable or substitutable on the same market (Hornborg, 2016: 62); and
iii. interest-bearing assets that in a capitalist economy can accumulate financial value so as to generate flows of money dividends (Read and Scott Cato, 2014: 155; Nadal, 2016), and that can be leveraged through credit/debt and securitization mechanisms.

In other words, thinking of nature as capital engenders confusion rather than clarity. Although rarely explicitly foregrounded, framing (cf. Lakoff, 2010) and thus cognitively conceiving of nature-as-natural-capital always begs the question: is the focus of attention on maintenance costs, possibilities for substitution, or dividends? Whatever the answer to this question, it is noticeable that the metaphor works by pulling attention *away from* the diverse biophysical entities of which nature is comprised and *towards* any or all of these different 'dead', albeit variously 'liquid', capitals (as discussed in Cooper, 2000; Büscher, 2013; Read and Scott Cato, 2014; Walker, 2016).

At the same time, for variously conserved natures to be fabricated as countable capital in any of the above aspects, they need to be signified numerically and priced (Helm 2015: 110, 116). In the next section, then, I explore some methods and applications through which aspects of nature *qualified* as capital are also being imagined, articulated and performed as units that can be quantified, accounted for and priced as such.

Dimension 2: Accounting for 'nature' as 'natural capital'

Hawken (1999: xiii) asserts that "capitalism cannot be fully attained or practiced [*sic*] until... we have an accurate balance sheet" that places 'natural capital' on "on the balance sheets of companies, countries, … [and] the world". In the last few years, a series of connected transnational governance endeavours has indeed been underway to account for nature-as-natural-capital on corporate, national and international accounts (see *UNEP-FI and GCP, 2013*: 38, and the various TEEB reports[17]).

In the corporate world, for example, the WBCSD, with the assistance of global accounting firm PricewaterhouseCoopers and a staff secondment from IUCN, have developed an influential 'Corporate Ecosystem Evaluation' (CEV) methodology (*WBCSD, ERM, IUCN and PwC, 2011*). CEV introduces a detailed accounting methodology to facilitate "better-informed *business decisions* by explicitly *valuing* both *ecosystem degradation* and the *benefits* provided by *ecosystem services*", defined as flowing "from natural capital" (*WBCSD, ERM, IUCN and PwC, 2011*: 4, emphasis in original). CEV is now promoted as a core valuation technique in the Natural Capital Protocol developed by the global Natural Capital Coalition (*Natural Capital Coalition, 2015a*).

At a national level, the Green Accounting of Indian States Project, funded by Deutsche Bank India, Centurion Bank of Punjab and Green Indian States Trust (GIST) and co-authored by the leader of the TEEB project, affirmed in 2006 that: "biodi-

versity should be treated as an asset and its loss should be adequately represented in the national accounts", at the same time as functioning as 'natural capital' that can represent genuine net additions to accounted for national wealth (*GIST, 2006*: 3, vii). In the UK, the government's Natural Capital Committee is charged with better integrating "the value of natural capital into decision making at all levels" and "creating and trialling an experimental accounting framework that organisations can use to value the natural capital they own or are responsible for"[18] (discussed further in Sullivan and Hannis, 2017).

At a global level, and invigorated by the Rio+20 'Earth Summit' in 2012, a number of significant interventions have recently been publicised for more robust and transparent 'green accounting' that incorporates non-manufactured environmental elements. The WAVES (Wealth Accounting and Valuation of Ecosystem Services) initiative of the World Bank Group (WBG), as a key element of the Bank's new 'Environment Strategy' (*World Bank Group, 2012a*), comprises a methodology for incorporating 'natural capital' and ecosystem measurements into national 'wealth accounts', in part "to establish the true value of biodiversity" (*World Bank Group, 2012a*: 48, 51; *WAVES, 2012*). WAVES extends a World Bank trajectory of "Expanding the Measure of Wealth" (*World Bank, 1997*; see discussion in Wilshusen, 2014: 133–134). It is set within the context of a substantially energised System of Environmental-Economic Accounting (SEEA), agreed in 2012 by the UN Statistical Commission as an international standard for combining economic and environmental data, including 'natural capital' and 'ecosystem services', into a single global accounting system (*EC et al., 2012*; *UN SEEA, 2012*; *WAVES, 2012*: 10). At the Rio+20 event in 2012, and amidst an array of interventions resisting a corporate-led 'green economy'[19], powerful networks (including the WBCSD) and financial institutions issued the 'Natural Capital Declaration' (NCD). This is a private sector voluntary finance initiative signed by the CEOs of financial institutions which, as noted above, commits the financial sector to voluntarily mainstream 'natural capital' considerations into all financial products and services (*NCD, 2012*). The NCD was followed in June 2013 by publication of the NCD 'Roadmap' providing further details and advice regarding implementation of the commitments made in the declaration (*UNEP-FI and GCP, 2013*). As well as creating inter-organisational corporate alignments around 'natural capital' (cf. Miller and O'Leary, 2007), an objective of this roadmap is to "[d]evelop practical tools and metrics to integrate natural capital into all asset classes and relevant financial products" so as to increase the visibility of 'natural capital' "on the balance sheets of financial institutions" (*UNEP-FI and GCP, 2013*: 4). Natural capital accounting is also being mobilized to demonstrate the extent to which economic activities create costs in the form of running down the capital value of natural capital (e.g. *Trucost Plc and TEEB for Business, 2013*).

These initiatives aim to generate balance sheet structures (*eftec, RSPB, PwC, 2015*: iii; also collection edited by Jones, 2014) that account for risks and opportunities posed by economic reliance and impacts on environmental parameters. In doing so they extend into environmental domains an older social accounting and "full cost accounting" impetus to account for those social costs that conventionally have been external to financial transactions (see discussion in Gray and Bebbington 2001[1993]; Milne, 2007). Natural capital accounting practices propose numbering and calculative applications to generate mathematical objects as a new set of numerical entities fabricated through practices of numerical abstraction and the creation of commensurability between these thus numbered entities. Through these numbering acts, mathematical objects are vested with the power to act as surrogate or proxy measures that represent the productive nature aspect under consideration. These surrogate numbers are then economized, i.e. are connected with some notion of market performance as denoted by priced values (cf. Lohmann 2009; Moor and Lury, 2011: 442; Helm, 2015). As Hornborg (2016: 70–71) asserts, since economic value is "a concept deriving from the market … the only conceivable metric for measuring it is money", despite the rather obvious fact that nature thus described "has itself no use for money".

Monetized values for 'natural capital' and 'ecosystem services' tend to arise through indirect methods including contingent valuation (such

as estimates of 'willingness to pay' for specified aspects of nature), or 'benefit transfer'. In these techniques, valuation is projected from unit values (dollar estimates of economic value on a per-unit basis) derived from particular use and non-use values measured at specific different sites (for overviews of techniques, see Pearce et al., 1989; Pearce, 1998; *WBCSD, ERM, IUCN, PwC, 2011*; *Natural Capital Coalition, 2015a*: 6–7). Frequently, valuation techniques involve the use of 'dummy' or proxy numerical variables to stand in for qualitative observations (see *GIST, 2006*: 15–19 for worked examples). Estimated discount rates may also be applied that pull estimates of the worth of future environmental health and damage into present calculations of value (Roberts, 2012). These accounting and valuation techniques generate numbers for nature units that are in monetary terms – thereby valuing nature "in terms of non-nature" (Read and Scott Cato, 2014: 162). These monetized values can then be made to work for cost-benefit analyses and cognate economic and accounting models. Table 2 distils the interconnected layers involved in arriving at these numbers, with examples worked through further below.

In 'sum', iterative processes of abstraction, counting and measurement are applied that conceptually *extract* 'entities' from the broader relational assemblages in which they are embedded (cf. Castree, 2003; Fourcade, 2011). This extraction enables the fabrication of 'natural entities' as atomised units that can be counted as cardinal numbers signalling quantities that can subsequently be added together to indicate aggregate values (on such numbering practices see discussion in Crump, 1992: 68–69, 77, 89; also Dauguet, 2015). Aspects of nature numbered in this way are able to undergo a further ordering in which counted quantities are utilised to create ordinal rankings of the numbers signalling levels of nature-value (Layer 3 in Table 2). It is this particular fabrication that guides offset exchanges or 'trade-offs' between sites of harm and health so as to facilitate an apparent 'no net loss' of the numbered quantity in aggregate (discussed further below). At every step of this process, specific value-laden choices shape the entities that become counted (see broader discussion in Maier, 2013), whilst also continually creating new externalities that overflow these calculations (Lohmann, 2009, 2014: 178).

Having delineated these relatively consistent and constructive layers in emergent 'natural capital accounting', I now work through three examples of their application at different scales of

Table 3. Identification of six interacting and stabilising layers of qualification, numbering/calculation, commensuration and monetization/pricing practices involved in making nature health and harm (ac)countable on balance sheets, based on close reading of nine interconnected policy texts as referenced.

Layer	Fabrication	Indicative source documents
1	Qualification / selection / measurement of aspects of 'nature' as 'indicators' of 'environmental assets', 'natural capital' and 'ecosystem services'	*GIST, 2006*: 3; *Wentworth Group*, 2008: 8; *Natural Capital Committee*, *2015*: 18
2	Conversion of units of selected environmental indicators into a single numerical metric that can act as a 'currency'.	*Wentworth Group, 2008*: 8 *eftec and IEEP, 2010*; *DEFRA, 2012*: 7
3	Numerical scoring, rating and 'trading-off' of these numbered indicators against each other, between places and over time. Aggregate values for an indicator may thereby be maintained (numerically at least), despite exchanges between sites of loss and gain. These leads to a 'no net loss' in the overall 'balance sheet' of indicators.	*GIST, 2006*: vii; *Wentworth Group*, 2008: 8; *WBCSD, ERM, IUCN, PwC, 2011*: 4; *eftec, RSPB, PwC, 2015*: iii; *Natural Capital Committee*, *2015*: 18
4	Application of valuation techniques that involve a monetizing and pricing dimension.	*GIST, 2006*: 3; *WBCSD, ERM, IUCN, PwC, 2011*: 12; *UN SEEA*, 2013; *Natural Capital Committee*, 2015: 18, 21
5	Combination of the above steps into a linear sequential methodology.	*WBCSD, ERM, IUCN, PwC, 2011*; *Natural Capital Coalition, 2015b*: 6–7
6	The identification of policy actions influenced by the information generated through the above procedures.	*Natural Capital Committee, 2015*: 2

analysis (local/regional, national, global), demonstrating the similar principles at work at each of these scales.

Maintaining aggregate renewable natural capital through small-scale biodiversity offsetting in England

Biodiversity offsetting (BDO) is proposed as a technique for maintaining renewable natural capital "in aggregate" (*DEFRA, 2012; Natural Capital Committee, 2015:* 70; Helm, 2015). In England, BDO is an option that becomes available for organisations causing detrimental impacts to biodiversity if other conservation activities urged by the mitigation hierarchy (avoid, minimise, restore) have been exhausted. BDO methodologies create equivalence in biodiversities at different places and times and thereby facilitate compensatory mitigation. The aim is to confirm a measurable 'no net loss', and preferably a 'net gain', in numerical indicators of 'biodiversity' over a larger scale of observation, even though losses have occurred through development impacts at specific sites (*BBOP, 2012*; see discussion in Sullivan, 2013c; Sullivan and Hannis, 2015). Portfolios of biodiversity damages may thereby be compensated for by portfolios of conservation investments elsewhere (as advocated in Pearce and Turner, 1990; see review in Spash and Clayton, 1997: 157–158).

In England, BDO is currently guided by a non-mandatory numerical metric developed by DEFRA and associated consultants (*eftec and IEEP, 2010*) (see Table 4). This calculative device disaggregates subjective scores for condition and distinctiveness applied to areas of habitat[20], such that different places and times can become counted in equivalent numerical terms.

Metrological devices like the DEFRA BDO metric are intended to standardise measures, thereby creating certainty and precision. Case research indicates, however, that in application this metric is mobilised in diverse ways (for example Burrows, 2011). Studies of BDO contracts as they are negotiated in practice suggest that scoring practices are contentious and frequently struggled over, particularly when these numbers translate into prices for offset payments (see Carver and Sullivan, 2017; Sullivan and Hannis, 2017). In application, then, such standardising devices can in fact generate *im*precision that then enters recommendations for compensatory measures, as well as creating conflict over what the correct numbers are that represent losses and gains of the environmental measure under consideration.[21]

Observed struggles over arriving at the 'right' numbers for habitat and biodiversity values are in part related to the inescapable subjective element in applying habitat scores. To provide a hypothetical illustration, in Table 5 a selection of three habitat types is scored using the online biodiversity calculator devised by the BDO brokerage firm, The Environment Bank Ltd[22]. The table shows the different outputs generated when condition is scored first as 'good' for each habitat type, and then as 'poor'. Of course, the expectation is that subjective scoring of habitats is supported by site visits and expert assessment. What this simple example illustrates, however, is that different scores attached to observed natures through these scoring practices can produce large divergences in numerical values for predicted impacts. In 'real world' cases of the application of this BDO metric economic, political and other interests have been observed to shape the weighting of values (Sullivan, 2013c: table 2; Carver and Sullivan, 2017; Sullivan and Hannis, 2017). This means that application of the DEFRA metric can generate diverse numerical outcomes for the same areas thus numbered. Such divergences and the (perspective-dependent) errors they may introduce have implications for calculations of aggregate values at larger scales.

Table 4. Habitat scoring system for biodiversity offsetting in England. Source: *DEFRA, 2012:* 7.

		Biodiversity distinctiveness		
		Low (2)	Medium (4)	High (6)
Habitat condition	Good (3)	6	12	18
	Moderate (2)	4	8	12
	Poor (1)	2	4	6

Table 5. Hypothetical example of two iterations of habitat condition scores ('good' and 'poor') made using the online biodiversity calculator for developers and landowners designed by the Environment Bank Ltd[23].

Habitat type	Hectares	'Biodiversity Value' in # 'biodiversity units'	
		habitats scored as 'Good'	habitats scored as 'Poor'
Intensively managed horticultural land	4	24	8
Amenity grassland	8	48	16
Native broad-leaf woodland	6	108	36
Total 'biodiversity units':		180	60

The 'aggregate natural capital rule', UK

Applications of BDO suggest it is hard to generate robust numerical calculations of damages to biophysical entities that can confirm a 'no net loss' of such entities over wider spatial and temporal scales. Nonetheless, 'aggregate rules' and calculations of total economic values are becoming entrenched in natural capital accounting, making it possible to claim that damage in one place or time can be neutralised through gain in a different place and time, so as to maintain numerical and economic (priced) values for natural capital in aggregate. At a national level, the UK government's Natural Capital Committee promotes an aggregate natural capital rule permitting losses and gains to be exchanged between different 'capitals', the thinking being that 'no net loss' may be calculated as occurring in aggregate and that 'natural capital' overall has thus been 'maintained' (Helm, 2014, 2015; Mace, 2014). A key intention of national natural capital accounts is to calculate stocks of nature-as-natural-capital (i.e. overall) in such a way as to support maintenance of measured elements above relevant thresholds (echoing Boulding, 1966, see discussion in Spash and Clayton, 1997: 145). Maintenance 'in aggregate' productivity and economic growth is connected with permitting substitutabilities between calculated values for different types of capital, as well as between different types of 'natural capital' (at the broadest level between 'non-renewable' and 'renewable' natural capitals) (discussed at length in Helm, 2015). This, then, is a compensatory approach advocating, for example, that exploitation of a non-renewable resource should be matched by investment in a renewable 'substitute' (Daly, 1990, discussed in Spash and Clayton, 1997: 157). Figure 1 represents the aggregate natural capital rule in schematic form, depicting current levels of national 'natural capital' as the (already

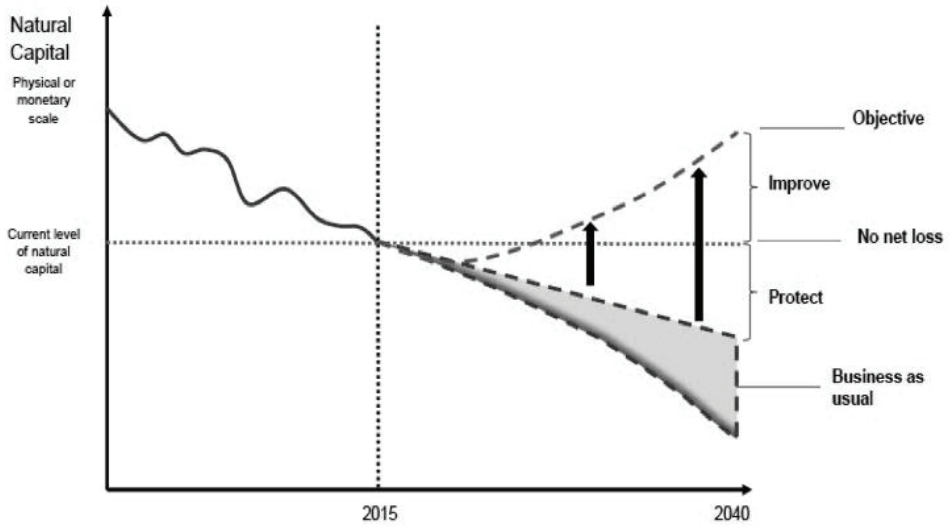

Figure 1. Schematic representation of 'natural capital' trends in the UK leading up to 2015 and thinking forwards towards 2040, indicating a framing of natural capital in aggregate terms, from which 'no net loss' is the desired aim of natural capital accounting, asset maintenance and investment. Source: *Natural Capital Committee (2015:* 7).

greatly depleted) level that should be sustained and improved so as to ensure 'no net loss' into the future.

Establishing "a set of properly maintained and enhanced natural assets" (*Natural Capital Committee, 2015*: 1) is associated here with the attribution of monetary value for these assets (reviewed in more detail in Sullivan and Hannis, 2017). The UK's Office of National Statistics, in partnership with DEFRA, thus recently produced an initial estimate of the 'aggregate', i.e. total, value of natural capital in the UK as approximately £1.6 trillion (*ONS, 2014*). This figure is calculated more-or-less indexically (i.e. based on measured quantities of material entities) (see for example *ONS, 2016*), but also acts iconically so as to perform an order of value from 'nature' (after Verran, 2013). This iconic performance, however, acts additionally to conceal various discounted elements. These include:

i. the instrinsic non-substitutabilities of *man-made* capital(s) (as reviewed in Spash and Clayton, 1997: 146–147; Read and Scott Cato, 2014; Nadal, 2016);
ii. the values-in-themselves embodied by elements of 'natural capital' and their interrelationships into the future (Spash and Clayton, 1997: 154);
iii. the socio-economic causes of ecological decline as depicted in Figure 1.

With respect to the latter point, natural capital thinking promotes financial reward structures to incentivize a shift in practices by existing producers and land-owners into 'green economy' renderings (of which BDO is one, see above). Little attention is paid to the ecological debt experienced by broader society that often has been generated through historical productive and appropriation practices associated with these same actors (discussed further in Sullivan and Hannis, 2015; Sullivan, 2017).

Aggregate rules in generating a global green economy

These perhaps 'anti-ecological' and 'anti-social' aspects of natural capital logics notwithstanding, balance sheet and aggregate rules are also increasingly important at the global scale, particularly in the management of carbon emissions and sinks. Notions of global 'zero-carbon' and 'net carbon neutrality' are being reinforced as critical for climate change management (see review of the UNFCCC Paris Agreement in Reyes, 2015). These notions indicate a consolidation of aggregate thinking in the international environmental policy arena. They propose management around measurable aggregate levels that should be maintained. Possible substitutabilities between the materialities calculated as constituting this aggregate are thereby permitted (as detailed in Lohmann, 2009, 2014). In carbon management, this means that fossil fuels can continue to be burned since their emissions may be offset through purchase of validated certificates representing carbon additionalities beyond a counter-factual scenario without a formalized carbon market (Ehrenstein and Muniesa, 2013). As discussed further below, such aggregate budgets, coupled with market mechanisms asserting prices for measured and thus numbered carbon units in standing forests, are leading additionally to new capitalizations of this counted carbon as a form of 'natural capital'.

This section has elaborated some mechanisms whereby by nature conceptualised and thus qualified as capital is being quantified, accounted for and exchanged as such. Similar enactments of numbering, aggregate rules and exchangeability have been highlighted for different scales of analysis and for different environmental units for which frequently subjective evaluations are applied that nonetheless create numerical comparability and commensurability. The next section traces some of the institutional work being enacted so as to enable these numbered and monetized fabrications of 'natural capital' to be leveraged in financial terms.

Dimension 3: Leveraging natural capital: the financial materialisation of numbers denoting 'nature'

> There's an emergent view that natural capital is the new asset class for the future.
> (Peter Carter, formerly Chief Environmentalist, European Investment Bank (EIB), summing up final session on finance at the conference *To No Net Loss of Biodiversity and Beyond*, London, June 2014, personal notes)

> Conservation finance … needed to preserve healthy ecosystems on land and in the oceans, and with them the earth's natural capital stock of clean air, fresh water and species diversity … represents an undeveloped, but emerging private sector investment opportunity of major proportion. (*Credit Suisse and McKinsey Centre for Business and Environment, 2016*: 3).

The preceding two sections document ways in which 'nature' is being both *qualified* and *quantified* as 'natural capital'. In this section I present examples of how nature-as-natural-capital is being *materialised* as financial capital. I draw on work being conducted by financial institutions and collaborators to create 'natural capital' as a major new asset class, and thereby to make "conservation finance investable" (Huwyler et al., 2014). A range of financial products, instruments, mechanisms and funds are being fabricated in this regard, including various green bonds, climate bonds and rainforest bonds. Work is being undertaken to mobilize and accelerate such conservation finance, so as to transform this 'asset class' from "niche to mainstream" (*Credit Suisse and McKinsey Center for Business and Environment, 2016*). The aspiration is to capitalize the scarcity of "Earth's last healthy ecosystems" into a profitable private sector investment opportunity of "major proportion" (Huwyler et al., 2014; iterated by Huwyler and two co-authors in *Credit Suisse and McKinsey Center for Business and Environment, 2016*).

Loans financing green economy projects deemed to support natural capital beyond a projected 'counterfactual' of 'business-as-usual' increasingly take the form of various financial bond structures. To date, these 'green bonds' have focused on financing infrastructure developments considered to assist with a transition to a low carbon or 'green' economy. Climate bonds and green bonds 'frontload' future funds by encouraging government borrowing from investors with the debt secured on future economic and environmental (especially climate) benefits expected to flow from these investments (*Climate Bonds Initiative, 2009*: 2, 4; discussed further in Sullivan, 2013b). The World Bank Treasury thus currently issues a variety of bonds secured on climate-related goals, including 'Cool Bonds'[24], 'Eco Bonds'[25] and 'Green Bonds'[26]. In the UK, 'environmental bonds', including 'green investment bank bonds, green infrastructure bonds, and woodland creation bonds' issued by either the government or the private sector, have been encouraged as a means of linking investment to pledges of environmental improvement by bond issuers (*EMTF, VNN and GHK, 2012*: 22, 32, 57–58; *EMTF, 2013*). Targeting an emerging class of investors in 'sustainability', the global market in 'green bonds' was estimated to be US$41.84bn in 2015, up from US$36.59bn in 2014[27], and is projected to rise to between US$55bn and US$80bn in 2016 (Ridley, 2016: 5[28]).

Increasingly, bond structures are being designed so as to leverage, i.e. materialize, financial value from the natural capital of 'standing natures' from which 'dividends' may flow through, for example, payments for ecosystem services and carbon values (*WWF, GCP, Climate Bonds Initiative, Goldman Sachs and Lombard Odier, 2011:* 5–6; *GCP, 2011*; *Bretton Woods, 2014*; *Credit Suisse, WWF and McKinsey&Company, 2014*; *Credit Suisse and McKinsey Center for Business and Environment, 2016*). The standing forests and other ecosystems of the global south are thereby fabricated as a store of projected natural-capital-based income streams that can be leveraged so as to service new conservation-impact-related financial products secured on their potentially legible value (discussed further in Sullivan forthcoming). In recent years, an array of reports arising through articulations between environmental NGOs, consultancies and financial institutions, have thus urged that public-sector funds and incentives such as tax breaks be mobilised to support private-sector investment in forests and other conserved ecosystems. As indicated in Figure 2 and associated references, investments would be linked to government issued bonds, purchased via brokers by private sector investors and based in part on the anticipated future incomes offering 'repayments' from the 'standing natures' thus invested (also see *Forum for the Future and Enviro-Market Ltd, 2007*; *WWF, GCP, Climate Bonds Initiative, Goldman Sachs* and *Lombard Odier, 2011:* 5–6; *GCP, 2011*; *EMTF, VNN* and *GHK, 2012:* 56).

In April 2015, for example, ADM Capital[29], an investment manager seeking long-term capital appreciation through opportunities in Asia and

Eastern Europe, with the environmental NGO (ENGO) Flora and Fauna International[30], launched a $1billion bond programme in 'Rainforest Impact Bonds' as a finance mechanism for tropical forest conservation that stimulates green economic growth (*ADM Capital, 2015*). This initiative has been boosted in 2017 by a new grant to support the design of a Tropical Landscapes Finance Facility (TLFF) and Tropical Landscapes Bond (TLB), developed in partnership with UNEP, ICRAF (the International Center for Research in Agroforestry), and the bank BNP Paribas (Genasci, 2017). These bond structures are designed in connection with sovereign aid commitments from developed countries to stem global climate change by reducing forest carbon emissions through deforestation and habitat degradation. As indicated schematically to the left of in Figure 2b, the flow of repayments to investors in Rainforest Impact Bonds is thus projected to derive from newly commodified and marketable carbon values in tropical forests whose value has been made legible in part via sovereign aid commitments derived from public monies.

ADM Capital is not alone in voluntarily creating financial products linked with projected returns from capitalised values accruing to standing tropical natures. The Althelia Climate Fund is one of a handful of investment funds raising capital to invest in emerging markets associated with REDD+[31], and Payments for Ecosystem Services (PES) markets (Abusaid, 2011; see review in Kill, 2016). Established and managed by asset management platform Althelia Ecosphere, and advised by Ecosphere Capital LLP and environmental NGO Conservation International, the fund is working through REDD+ accounting to bind legible natural capital carbon values embodied by standing tropical forests to investors from elsewhere. These investments are deemed to create "new environmental assets that reflect the value of natural capital"[32]. Initial investments in Althelia from the EIB amongst other investors totalled $80 million in June 2013, enhanced with more than $130 million lent from the USAID in 2014[33]. The fund, asserted as fully invested in 2017 (*Althelia Ecosphere, 2017*), comprises "a diversified portfolio of investments in Africa, Latin America and Asia that take the form of real assets (certified commodities and agricultural produce) and environmental services (verified emissions reductions and other ecosystem services [including carbon accounted for under REDD+[34]])" that will deliver "cash dividends to investors" *(Althelia Ecosphere, 2013:* 1*)*. Althelia Ecosphere states that "[e]cosystem goods and services from Natural Capital" are "worth trillions of US dollars per year" (*Althelia Ecosphere, 2013*: 3), projecting this value to materialise from "future streams of payments for expected emissions reductions" *(World Bank Group, 2012b:* 1*)*.

More recent proposals emphasise possibilities for scaling-up conservation investments from institutional investors and (Ultra-)High New Worth Individuals ((U)HNWIs), i.e. the super-super-rich, through financial products linked with emerging or predicted conservation markets (Huwyler et al. 2014: online; also *Credit Suisse, WWF* and *McKinsey&Company 2014*; *Credit Suisse* and *McKinsey Center for Business and Environment 2016*). As stated in all these reports, investors loaning finance to projects associated with conservation expect returns from their investments. Again, these returns are projected to materialise in part from new markets in ecosystem services and carbon. Indeed, in October 2016 the first forestry bond was issued that repays its investors with either cash or carbon credits generated from avoided emissions through reduced deforestation in Kenya's Kasigau Corridor, invested in via the portfolio of the Althelia Climate Fund mentioned above. Issued by the International Corporation (IFC) of the World Bank and developed with mining conglomerate BHP Billiton and ENGO Conservation International, this "[i]nnovative $152 million bond to protect forests and deepen carbon-credit markets" (Klopfer and Panjyan, 2016) represents the first link between two accounting modes in green finance architecture: the green bond market and the carbon-accounted offset market. The bond is designed to scale-up private sector climate change finance and conservation liquidity, albeit in a context of concern regarding local socioeconomic impacts of offset provision (Chomba et al., 2016). In these new impact-related conservation finance structures, investor risk is projected to be reduced through mobilising such newly legible-leverage-

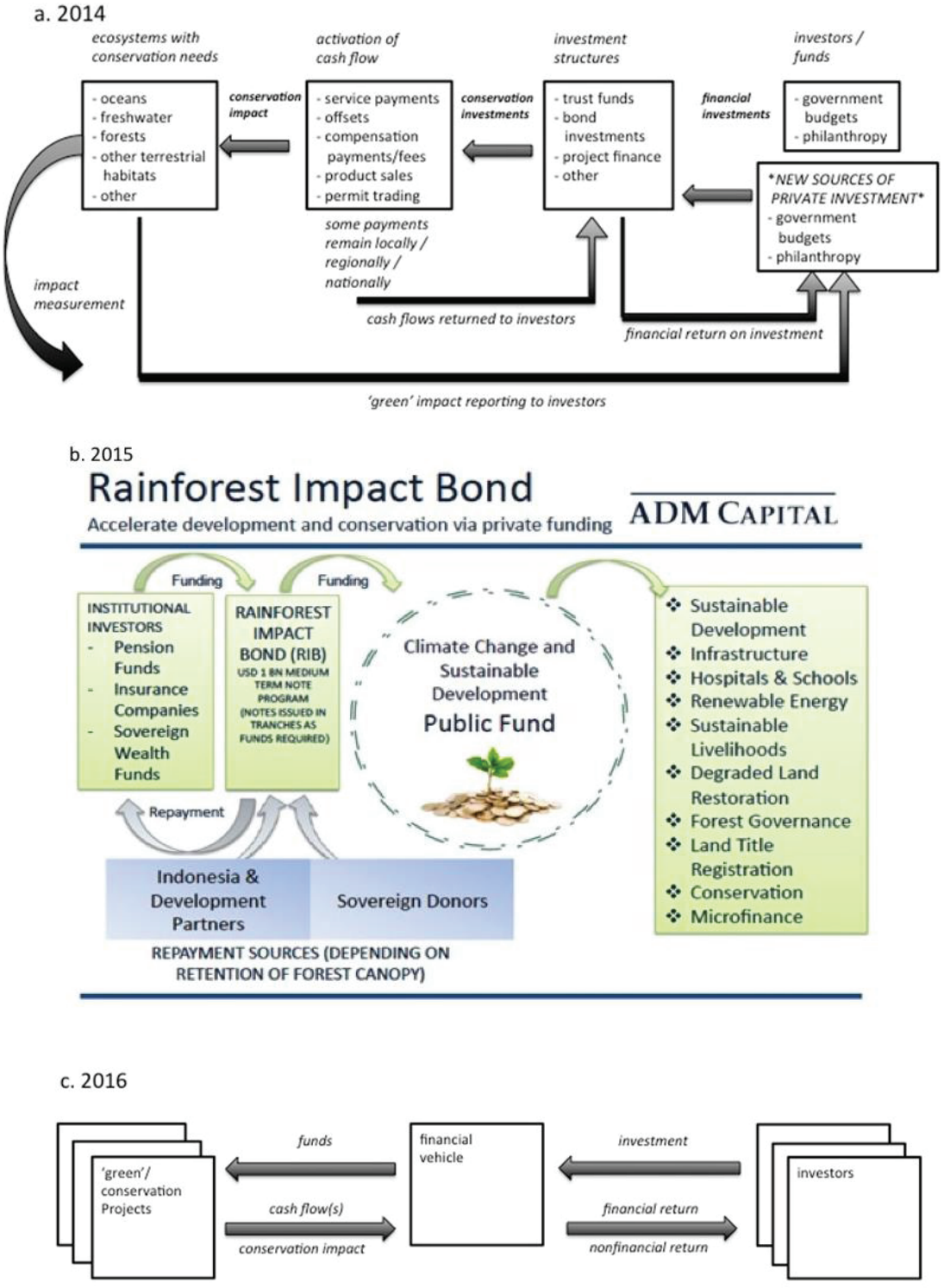

Figure 2. Versions of schematic representations of new forms of private sector conservation finance leveraged on increasingly legible natural capital value flows: **a.** Conservation finance framework, redrawn from Credit Suisse, WWF and McKinsey&Company (2014: 11) **b.** Rainforest Impact Bonds, source: ADM Capital (2015); **c.** 'Demand and supply side of conservation finance', redrawn from Credit Suisse and McKinsey Center for Business and Environment (2016: 9).

able assets and the 'land or usage rights' from which they derive as underlying collateral (see, for example, *Credit Suisse* and *McKinsey Centre for Business and Environment*, *2016:* 17).

These financing proposals imply that countries of the global south with remaining high levels of globally valuable living 'natural capital' may become indebted to ultra-high-net-worth investors who will access returns on their investments from new income streams arising from conserved tropical natures. These possibilities are likely to be boosted through recent UNFCCC consolidation of an approach to global carbon management that emphasises an aggregate "balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases" (UNFCCC Paris Agreement 2015, Article 4.1), thereby consolidating global carbon management through offsetting, including through purchase of tropical forest carbon (Ehrenstein and Muniesa, 2013). At the same time, such structures are emerging in a context of poor standardisation and verification practices and guidelines, and few safeguards. Practices fall far short, for example, of established mandatory asset valuation rules detailed for real estate, infrastructure and construction in the UK (Royal Institute of Chartered Surveyors, 2014), or for the harmonisation of property valuation practices in Europe (The European Group of Valuers' Associations, 2016).[35] This 'gap' is now potentially being filled by a 'cottage industry' of valuers and verifiers (Ridley, 2016: 4), which perhaps in time will mirror the army of professional auditors swarming around carbon valuation, verification and trading (Lohmann, 2009, 2014; Ehrenstein and Muniesa, 2013). A host of opportunities thus also exists for diverse intermediaries to find and create niches in new natural capital audit and investment structures (Munden Project, 2011; Sullivan, forthcoming).

What we have in the examples above, then, is a financing approach in which nature's qualification as the fact(ish) of 'natural capital', coupled with its quantification through (ac)counting and valuation technologies, is permitting translations of these emerging natural capital quantities into financially material, i.e. leverageable, forms of value. In my next and final section I briefly consider some of the broader implications of this capitalization of 'nature'.

Conclusion: The forward-driving force of (natural) capital?

> It is certainly a complex exercise to put a value on natural capital, although that value becomes clearer once it becomes scarce (*van Herwijnen* [Responsible Investment Analyst], *2016*: 2).

> Capital is the driving force of the series of payment exchanges: money in the making; money beyond money. At each payment, a punctual return is made to capital. Profit is fed back into investment, replenishing the forward-driving force of capital. Money loops from its punctual exercise as means of payment into a feeding of the conditions of its own continuing. (Massumi, 2015: 72).

This paper has documented a series of articulations whereby the external(ised) 'Nature-whole' of 'nature' is being fabricated metaphorically and materially as 'capital'. Through these fabrications, technical 'modes of existence' (Latour, 2013) in environmental and economic spheres of activity are combined as a response to global crisis in both these spheres (Sullivan, 2009). Notwithstanding the diverse dimensions of 'capital', detailed above, in each application of the natural capital metaphor entities become defined through a category distinct or apart-from their immanent, dynamic materialities (cf. Cooper, 2000; Joronen, 2013: 627). An 'illusion of equivalency' between materialities in their conception as 'capital(s)' is thereby fabricated and sustained (Wilshusen, 2014: 138). Monetized numbers bringing 'natural capital' into iconic presence in the world act additionally to assert factual status even though their object is so "ineluctably vague and spatially indeterminate" as to be unquantifiable with any deep certainty (Verran, 2013: 34; also Dauguet, 2015). In addition, and despite desires for standardization (cf. *Natural Capital Coalition, 2015b*: 3) and the production of certainty, a proliferation and hybridization of calculative tools is being generated (also Mennicken and Miller, 2012: 19). Indeed, this aspect has been observed for a range of social and environmental domains into which accounting practices have been extended, and perhaps is intrinsic to this expansion: see Moor and Lury (2011) for calcula-

tions of brand value; Lohmann (2009, 2014) and Lippert (2014) for corporate carbon accounting; the list of tools in *Natural Capital Coalition* (*2015a*); and Carver and Sullivan (2017) for BDO metrics.

The above observations indicate that a series of category errors may be amplified in the metaphorical work that links 'nature' with 'capital'. Indeed, it seems important to ask whether a more appropriate metaphorical strategy for 'valuing nature' would be to propose and affirm metaphors that pull attention towards life's immanent diversity, unpredictability and liveliness, rather than towards the dead, albeit 'lively', artefact of money as a measure of all value (Read and Scott Cato, 2014; Hornborg, 2016). Category errors notwithstanding, the numbers linking 'nature' with 'capital' are becoming able to be invested so as to generate further financial value. This is the performative shift from legibility to leverageability to which my title alludes. The fabrication of 'natural capital' abstractions and articulations is thus indeed "a process of 'definition' or social construction in a substantive sense", as Fourcade (2011: 1769) writes.

The narrative woven together in this paper has drawn on multiple observations and documentations to suggest that a performative shift is taking place in the fabricating of nature-as-natural-capital, but is limited in terms of providing empirical detail for specific cases and contracts. This moving frontier is ripe for empirical, comparative and independent case research to trace and clarify specific fabrications and flows of value, combined with their financial, social and ecological effects, for selected financial(ised) products and their contexts (see, for example, the cases documented in Ehrenstein and Muniesa, 2013; Lippert, 2014; Carver and Sullivan, 2017). The articulations documented above, however, indicate that the increasing legibility of nature-as-natural-capital is consistent with a "calculated management of life" (Foucault, 1998[1976]: 140; discussed in Mennicken and Miller, 2012: 6) able to realise new financially leverageable values. These values seem additionally positioned to replenish the entrepreneurial and accumulative tendencies of a neoliberal governmentality oriented towards a truth regime of the market (Foucault, 2008[1979], discussed in Sullivan, 2013b: 211; Asiyanbi, 2017). These effects are especially clear when we consider some of the examples explored in Dimension 3 above. Here, the foregrounding of returns to large-scale private sector investors and (U)HNWIs appears set to complete possibilities for plutonomic captures of 'natural capital'. Through new mechanisms for debt-based impact investing in conservation finance, those contributing disproportionately to both environmental damage and to unequal wealth differentials appear potentially able to gain additionally from new revenue streams becoming legible from increasingly scarce 'standing natures'. To return to the advocacy of Schumacher in the 1970s with which I opened this paper, this emphasis seems diametrically opposed to the downsizing of economic activity he urged as an appropriate response to global environmental degradation.

The stakes of this enterprise are high. They promise nothing less than both measurable recovery of nature health through its enrolment and technical rendering in natural capital accounts; at the same time as offering routes whereby market growth can be sustained and amplified, in part through the better valuing of 'natural capital' that such accounting practices promise to perform. As emphasised by Mennicken and Miller (2012), however, the expansion of accounting into social and ecological domains also requires understanding as a *territorializing* activity, through which calculative, market and privatising regimes of governance extend into new areas of social and ecological life. In doing so, modalities of governing, as well as forms of personhood and power, are modified (Mennicken and Miller, 2012: 4), as are socioecologies that become thus valued and thereby governed. Indeed, although not emphasised in detail above, significant tensions arise as property rights over land, ecosystem services and carbon are of necessity individualised in processes of accounting for and selling new natural capital values (Ehrenstein and Muniesa, 2013). Formulating possible responses and resistances thereby requires both appreciation of the will to design and enact the new environmental-financing models detailed above, as well as understanding of the structures of investment products that wrap local peoples and ecologies further into global financial(ising) structures.

Incompleteness of translation, loss of precision in the layers of calculation, and unacknowledged ideological structuring, also constitute openings for poor financial performances (Dempsey and Suarez, 2016), multiple ecological and societal 'overflows' (Callon, 1998; Lohmann, 2009, 2014), 'counterperformativities' (Fredriksen, 2014) and 'pushbacks' (Bracking, 2015). Space does not permit a full discussion of the roughness contributed to natural capital thinking by these tendencies. We might simply conclude by observing that this is a productive and lively moment in the social fabrication of nature-as-natural-capital that invites critical and diagnostic attention.

Acknowledgements

I gratefully acknowledge research and writing support from the Leverhulme Trust (RP2012-V-041) and the UK's Arts and Humanities Research Council (AH/K005871/2), as well as invitations to participate in and present at the events mentioned in the paper. The paper has benefitted from comments on earlier drafts by Sarah Bracking, David Demeritt, Jessica Dempsey, Aurora Fredriksen, Mike Hannis and Peter Wilshusen, as well as two anonymous reviewers, for which, many thanks. Interpretations in the text are my responsibility alone.

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Notes

1 http://www.thefreedictionary.com/fabricate. Unless otherwise stated, all websites cited in this paper were accessed in February 2017.

2 http://naturalcapitalforum.com/

3 http://www.naturalcapitalforum.com/who-should-attend, accessed 10.11.2013.

4 http://www.naturalcapitalcommittee.org/

5 http://www.naturalcapitaldeclaration.org/

6 http://www.uncsd2012.org/

7 http://www.naturalcapitalcoalition.org/natural-capital-protocol.html

8 http://www.eib.org/products/blending/ncff/index.htm

9 http://naturalcapitalforum.com/about/

10 Also see Devadason (2011: 633) who critiques the creative rhetorical force of 'the metaphor of capital to represent sociable and normative aspects of everyday life'.

11 See, for example, http://www.mauricestrong.net/index.php/speeches-remarks3/34-asia; http://www.mauricestrong.net/index.php/speeches-remarks3/79-korea-economic-policy; http://www.mauricestrong.net/index.php/speeches-remarks3/46-scenarios, all accessed 21.05.2016..

12 http://www.slideshare.net/Denette/denettes-international-alliance-presentation, slide 2, accessed 21.05.2016.

13 http://encouragecapital.com/

14 http://www.defra.gov.uk/news/2011/06/07/natural-environment/, accessed 21.05.2016.

15 http://bankofnaturalcapital.com/

16 i.e. without extending the term to 'human', 'social' and 'cultural' domains, as delineated by Bourdieu 1986) in his use of 'capital' as 'a surrogate for [accumulations of] power', as well as more normatively in multiple development and corporate models (see discussion in Wilshusen, 2014: esp. 140-145; also Devadason, 2011).

17 At http://www.teebweb.org

18 http://www.naturalcapitalcommittee.org/

19 http://rio20.net/en/

20 As classified by the Joint Nature Conservation Committee, a public body that advises the UK central and devolved Governments on nature conservation (see http://jncc.defra.gov.uk).

21 As documented in exhaustive detail for the performativity of climate/carbon equations in Lohmann (2014).

22 http://www.environmentbank.com/index.php

23 http://www.environmentbank.com/impact-calculator.php

24 http://treasury.worldbank.org/cmd/htm/CO2LBond.html, accessed 18.05.2016.

25 http://treasury.worldbank.org/cmd/htm/Eco3PlusNoteInaugural.html, accessed 18.05.2016

26 http://treasury.worldbank.org/cmd/htm/WorldBankGreenBonds.html, accessed 18.05.2016

27 http://www.climatebonds.net/

28 Thank you to James Vause, Lead Economist, UNEP-WCMC, for drawing my attention to this presentation, pers. comm. 16.05.2016.

29 http://admcapital.com/

30 http://www.fauna-flora.org/initiatives/innovative-finance-for-conservation/

31 *i.e. the UN programme for Reducing Emissions from Deforestation and Forest Degradation in Developing Countries* (http://www.un-redd.org/), programmatic implementation of which is coordinated in particular by the Food and Agriculture Organisation (FAO), the UN Development Programme (UNDP) and the World Bank's Forest Carbon Partnership Facility (FCPF) (Kill pers. comm. 6 August 2017).

32 https://althelia.com/our-approach/

33 https://althelia.com/2014/05/29/usaid-announce-new-partnership-with-althelia/

34 i.e. the UN Programme for Reducing Emissions from Deforestation and Forest Degradation in Developing Countries, see http://www.un-redd.org/, accessed 21.05.2016.

35 Thank you to Tom West, Economics and Law Researcher (Biodiversity), ClientEarth, for encouraging consideration of this point, pers. comm. 16.05.2016.

Reviewing S&TS book reviews

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With this issue we (Brit Ross Winthereik and Helen Verran) sign off as book review editors, handing over to Vincenzo Pavone. We expect that in the next few years Vincenzo will have as much fun and frustration as we did in doing this job, and wish him well. We take this opportunity to offer a brief look at the history of book reviews in this journal.

Some data:

- Since 2012 every issue of the journal has carried at least one book review text (with the exception of two special issue editions). Between 1998 and 2011 book reviews were irregular yet generally appeared more often as years went on.
- Eighty-six books in all have been reviewed in the history of the journal, with two books being given juxtaposed dual reviews. Thirty-eight of these books were monographs, the work of one or two authors, the rest being edited collections of papers. Reviews of events and exhibitions (three) were introduced in 2016
- Three authors had more than one of their publications reviewed: Bruno Latour (three) Steve Fuller (two), Helen Longino (two).
- Gender balance of authors and reviewers were as follows: authors and editors: 34 women and 101 men; reviewers: 44 women and 49 men
- The most popular book topics were: digital technologies, epistemology, STS as scholarly discipline, and science policy.

After we took over as book review editors we attempted to get more women as reviewers and particularly to get more students. We encouraged supervisors to work with their students on book reviews and to publish as dual authors of reviews. In the current academic atmosphere where time for writing that does not immediately lead to any 'points'/product is difficult to find, we were keen to highlight – especially to young scholars – that book reviewing for S&TS do 'count' as they can be listed as publications on a developing CV.

We favoured reviews of monographs since we feel that edited collections are both difficult to review and even more difficult to review well. This attitude became harder and harder to sustain as fewer and fewer monographs are being published. In years past PhD theses often found publication in the form of monographs, something that is now becoming quite rare.

Table 1. Book reviews per year

1998	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2	2	2	5	5	6	5	2	4	3	1	3	5	6	7	12	11	4

A new phenomenon that has emerged over the past year or two has been the increasing difficulty of getting publishers to actually supply books for review other than the books they themselves like to see reviewed. As one publisher noted in confidence, increasingly publishing houses regard scholarly journals as competitors, especially open access journals. And publishers nowadays avoid investing in run-of-the mill edited collections of papers that arise in conferences, leaving that to the proliferating numbers of special interest journals only too willing to publish special interest editions.

In an attempt to encourage student book reviewers, a year or so ago we attempted to invent a new ritual in association with EASST meetings. We encouraged all those students who had been awarded EASST scholarships funding their attendance at the conference to accompany Brit around the press displays to choose a book for subsequent reviewing in S&TS. Unfortunately, there was little enthusiasm shown for this proposal and not one review has since been submitted. We had more success in interesting young scholars to review exhibitions and events however and hope this interest expands.

When it comes to publishing STS books it is particularly gratifying to note the emergence of the innovative Mattering Press, a press specialising in publishing books adopting STS approaches to analysis. Beginning as a graduate student co-operative at Lancaster University in the UK, Mattering Press has emerged as a new type of practitioner led scholarly institution. The attitudes fostered amongst a group of cooperatively minded students now pervades the editing processes with authors supported to produce the best book they are capable of, while remaining within the remit of the press as an STS press.

So, what were our hopes as we took over the task of eliciting and supporting the production of reviews of books, exhibitions and events for publication in S&TS? Of course, we expected scholarly reviews of rather than summary or opinion reviews such as you might find in newspapers or literary magazines. This was clearly news to some enthusiastic authors. This is one reason that we encouraged prospective reviewers, book authors, and publishers to contact us directly to discuss the prospect of a review. Encouraging direct submission of book review texts to the journal can create a lot of unnecessary work.

What characterises a scholarly book review, and are scholarly reviews of STS books different than reviews of say philosophy, sociology, or anthropology books? Adequacy as a scholarly text is not what is at issue in a book review in a scholarly journal, given that 'quality control' is more the task of the sponsoring institutions and organisations. In this sense a book review is quite different than a review of an article for publication in a journal.

A scholar carries a sense of the several originary moments in a scholarly tradition from which analytic currents remain strong, and which might carry practitioners into generative futures at any given point in time. Given that future prospects for analytic traditions are always variously difficult prospects, having a general sense of possible futures can often help to make a book review interesting. For example, humanities and humanist social sciences scholars are increasingly voicing concerns that funders and students are abandoning Hermesian interpretive disciplines in favour of income-earning Apollonian disciplines that focus on 'useful' knowledge'. Since STS often sees itself as a nexus between these, that can be a way of locating a review that takes account of general scholarly issues. In STS, generative transgression of disciplinary boundaries is generally encouraged, often in contrast to other disciplines, where disciplinary boundaries are often policed in book reviews. Having a sense of what is at stake in disciplinary geographies is another means of making an STS book review interesting.

Of course, the ideal of publishing reviews by informed and thoughtful reviewers is not always, or perhaps often, achieved. This is complicated when we go out of our way to encourage students to undertake reviews. Yet even a beginning reviewer can ask where does this publication sit in the streams of analytic developments that I understand as constituting my discipline? And asking how does the reviewer locate him or herself in those streams, is exactly the challenge many students need.

In concluding we thank those authors, editors and reviewers who have helped create such a lively European STS scene in the past few years. Let us urge you as STS practitioners to keep writing—both books and book reviews.

Science & Technology Studies

Volume 31, Issue 3, 2018