Nanotechnology Governance

Accountability and Democracy in New Modes of Regulation and Deliberation

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Abstract

Current discourses in science, technology and innovation policy describe a shift from formal, governmental, or statutory regulation to non-hierarchical, informal, and co-operative self-regulatory approaches. They narrate a turn from government to governance, described as a "governance turn." Governance as a new and popular mode of regulation, deliberation and shared responsibility is often linked to favored attributes of science and technology development, and policy making such as democracy and responsibility. This article analyzes the connection between governance and ideas of accountable and democratic science and technology development in the case of nanosciences and nanotechnologies. For this purpose, soft law measures, self-regulatory initiatives, and public engagement projects in Europe and the U.S. were analyzed using the concept of social robustness (Nowotny et al. 2001).

The study showed that most of the analyzed governance approaches and engagement projects only partially met aspects of social robustness, and that the governance and deliberative turn in science and technology policy has not led, so far, to greater democracy and responsibility in nanoscience and nanotechnology development. As a consequence, the delegation of techno-political decision making to less socially robust governance approaches might lead to a vacuum in science and technology policy and affect not only academic knowledge production but also the innovative force of a society.[1]

1 "New governance of science"?

The analysis of policy documents in the nanosciences and nanotechnologies (NST)—often subsumed under the term nanotechnology[2]—points to interesting aspects of perceived risks, regulatory need, and the question, which societal actors should become active in regulatory issues and decision-making in science and technology policy?

"Current legislation covers in principle the potential health, safety and environmental risks in relation to nanomaterials." (Commission of the European Communities CEC 2008, 3-4)

"Public health, environmental and consumer protection require that those involved in the development of nanotechnologies–including researchers, developers, producers, and distributors–address any potential risk, as early as possible." (CEC 2004, 22)

"In a first phase, self-responsibility of industry is of high significance." (CH-Bundesrat 2008, 3, 10-11, translation MK)

"We believe that a constructive and proactive debate should be undertaken now. We recommend that the Government initiate adequately funded public dialogue around the development of nanotechnologies." (RS&RAE 2004, xi)

"Experiments and innovations in public engagement with science have the potential to contribute to a more accountable science and a healthier democracy." (Wilsdon 2005, 1)

"Specific recommendation on how government and industry could improve trust [is] the provision of more information to the public." (Macoubrie 2005, 4)

These quotations frame the NST-related techno-political discourse in terms of four principles:

1. Policymakers agree that current legislation mainly covers the potential health, safety and environmental risks of nanomaterials. In general, they do not see an immediate need for additional legislation.
2. NST regulation is mainly framed in terms of governance, meaning non-hierarchical, informal, network-oriented, and cooperative forms of ruling such as soft law[3] and self-regulation. Hereby, the regulatory responsibility is shifted to the actors involved in the research, development, production, retail and disposal process of NST.
3. Public engagement is assigned high significance. However, the question of whether the approach is to be mutual-learning or information-oriented, is an issue (see, for example, the Wilsdon and Macoubrie citations above).
4. A connection is made between governance and democracy that links self-regulation, soft law and public engagement with favorable attributes such as accountability, stewardship, safety, sustainability, acceptance, public trust, democracy and the idea of responsible technology development.

These observations are not new. Since the 1970s, political scientists have observed a shift from hierarchical to more cooperative forms of regulation (Mayntz 1996). They narrate a turn from government to governance (Rhodes 1997)

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[2] The term nanotechnology is ambiguously used for all kinds of small molecular research, development, production and futuristic visions (cf. Lösch 2006). The term is also framed as an "empty signifier" (Wullweber, 2008), an "umbrella term" (Rip and Voss 2008), a "folk theory" (Rip, 2006), a "funding strategy" (cf. Kurath and Maasen 2006) or a "lack of reason" (Schummer 2009).

[3] The term "soft law" is used with regard to quasi-legal instruments not having any legally binding force, or whose binding is weaker than that of traditional statutory law—which in contrast to soft law is referred to as "hard law". Originally, the term "soft law" was mainly used for international law, although currently it has been transferred to other branches of domestic law as well, such as voluntary legal schemes by public authorities (cf. Kirton and Treblicock 2004; Nasser 2008). The term "self-regulation" will be used when societal actors are setting standards and monitoring compliance in the interest of public protection, (cf. Boekaerts 2005).

in which governance measures were framed as a substitute for statutory regulation within the context of neoliberalism and questions of effectiveness and efficiency of policy-making (Mayntz, 1996). Recent studies characterize this turn, depending on their analytic frame, as either a governance (Borràs and Conzelmann, 2007, Rose 1996), deliberative (Hagendijk and Irwin 2006, Irwin, 2006, Kearnes and Wynne 2007), or qualitative (Kearnes 2009) turn, or as a shift from a "modernist to postmodernist form of statecraft" (Gottweis and Petersen 2008).

A further framing of those new modes of governance by ideas of accountability, responsible technology development, and an increase in democracy has been described for the field of NST (see Kearnes and Wynne 2007). In this way, soft law, self-regulation, and public engagement have been framed as means for technology development that is—in Nowotny's words—socially robust (Nowotny et al. 2001, 167).

Soft law and self-regulatory approaches

This shift from statutory or "hard law" *federal* regulation (in the cases of the US, Germany, and Switzerland) to "soft law," self-regulatory approaches has been described in science and technology policy studies as a "new governance of science" (cf. Gibbons et al. 1994, Irwin 2006, Barben 2005, Felt et al. 2008, Lengwiler and Simon, 2009, Weingart 2001). Regulation of innovative, uncertain emerging technologies was reinterpreted as a task that no longer concerns traditional governmental institutions, but is instead negotiated at the interfaces between science, politics, industry and civil society (Miller and Rose 2008).

Public understanding of science and upstream engagement

Thinking about public engagement in science and technology-related decision-making processes[4] traditionally

has been done in terms of "public understanding of science" (PUS). Relying upon a commonly assumed expert-lay divide, PUS views public engagement mainly in terms of information, education, and dialogue with the public. It assumes that increased information and education of the public leads to increased trust and acceptance of science and technology. However, the PUS concept has been broadly criticized as a "deficit model" and "ill-defined" (cf. Wynne 1995, Irwin and Wynne 1996, Hagendijk 2004, Jasanoff 2005).[5]

In contrast to PUS, a newer conceptualization of public engagement in the early stages of technology development has emerged that is referred to as "upstream engagement" (Wilsdon and Willis 2004).[6] Upstream engagement aims at treating the public as an equal and regarding its knowledge in a mutual-learning-oriented way. This is considered central to emerging science and technology-related decision-making processes, and is framed as a more democratic science-society interaction and way of making science policy (RS&RAE, 2004). Following the RS&RAE (2004) report and a related Nature editorial (Nature 2004), upstream engagement became a fashionable term in science communication. A variety of deliberative and upstream engagement-related projects and communicative activities were initiated and advertised as

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[4] On public engagement and its popularization see e.g. (Hagendijk and Irwin 2006, Jasanoff 2005, Wilsdon and Willis 2004, Hagendijk 2005, Abels and Bora 2004).

[5] The focus on NST-related public dialogue varies between the analyzed countries. As an example it is not as intense in the U.S. as it has been in the EU, particularly in Britain and in the U.S., the public understanding of science (PUS) approach is still prevalent, as e.g. the last quotation on page 2 (Macoubrie 2005, 4) showed.

[6] Particularly in Britain, a generic deficit of public trust in science, technology, and political representatives has been broadly recognized (cf. Gaskell et al. 2004, Gaskell et al. 2005, Wynne 2001). Here, public controversies involving nuclear power, GMO, and BSE, have resulted in an early-stage initiation of dialogues, deliberation, and public engagement in the field of NST, with the aim of increasing public confidence (Hagendijk and Irwin 2006).

another democratic turn in the techno-political discourse (Kearnes et al. 2006b, see also Kurath and Gisler 2009).

Questions

This article focuses on the correlation of governance with accountability and democracy in the nanosciences and nanotechnologies. A selection of 14 self-regulatory and soft law schemes in NST, also described as regulatory-oriented governance (Section 3), and six public engagement projects, termed, 'deliberation oriented governance'(Section 4), will be analyzed regarding their social robustness. Among the questions asked are these:

1. Do the analyzed governance schemes and projects show concrete and robust approaches, outcomes, and results, or have they been restricted to declarations of intent only?
2. Have they established robust strategies regarding current policy discourses, the enforceability of their outcomes, and their translation into the political process?
3. Have they addressed the acceptability of their own approaches, methods, and outcomes?
4. Have they considered external social knowledge and how they engaged it?
5. Were they subject to public consultation and established external evaluation, testing, and improvement?

Socially robust knowledge

The concept of social robustness (Nowotny et al. 2001) was originally developed for the analysis of science and academic knowledge production in modern knowledge societies (Weingart 2001, Gibbons et al. 1994, Nowotny et al. 2001). It was based on the emergence of both a new mode of knowledge production and an increased permeability of the societal domains of state and science (Nowotny et al. 2001, 166).

Social robustness also was based on the observation of an intensified contextualization in academic knowledge production: scientists have increasingly been influenced and motivated by external factors such as their contribution to innovation, solving environmental, ethical, and societal problems, and to policy advice. This led to a shift from weakly to strongly contextualized knowledge production (Nowotny et al. 2001, 166). Strong contextualization of a scientific field or research domain leads to high social robustness of the knowledge it is likely to produce. Social robustness has been framed by five criteria (Nowotny et al. 2001, 167):

1. Social robustness is relational, or in other words, contextualized
2. Social robustness describes a process that generates stability
3. Socially robust knowledge is based on its acceptability by individuals, groups and societies
4. Socially robust knowledge is infiltrated and improved by social knowledge
5. Socially robust knowledge is subject to frequent testing, feedback, and improvement, or evaluation

Socially robust regulation

The openness of social robustness well matches the analytical needs of a study of societal processes or activities beyond science and academic knowledge production that include regulation, deliberation, public engagement and governance. Regulatory and deliberative oriented governance approaches could be more socially robust if they consider and include external contexts, generate stability, have been infiltrated and improved by social knowledge, and are subject to frequent testing, feedback, and improvement.

The criteria framing social robustness—contextualization, stability, acceptability, social knowledge and evaluation via feedback, testing and improvement structures (Nowotny et al. 2001, 167)—are open enough for this transition of focus. Their applicability to governance approaches makes social robustness suitable for this study's analysis of accountability and democracy of governance, self-regulatory measures, soft

law approaches, and public engagement projects.

A range of governance measures in the NST[7] were chosen for the analysis of these issues within an overarching qualitative comparative analysis of NST-related policy discourses in the US and Europe, including the European Union member states Germany and Britain, and nonmember state Switzerland.[8] Methods consisted of qualitative, semi-structured interviews (Lamneck 1988) with actors involved in science, politics, industry, and civil society organizations, as well as the analysis of relevant policy documents and assessment reports.[9] The analysis of public engagement projects is based on an earlier study conducted in 2007 (see Kurath and Gisler 2009).

2 Criteria for the analysis of social robustness

Analysis of regulatory and deliberation oriented governance schemes and projects, rely upon the following aspects of the concept of social robustness:

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[7] On the establishment of NST related governance measures, see e.g. (Maasen, 2009, RS&RAE 2004, Wilsdon and Willis 2004, Wilsdon 2005, Kearnes et al. 2006a, Nature 2004, Kearnes and Wynne 2007, Barben et al. 2008, Kearnes and Rip 2009, Lösch et al. 2008, and for a general overview Kaiser et al. 2009).

[8] The aim of this study was a transatlantic comparison. A direct comparison of the US and the European Union's supranational confederation of states might produce epistemological difficulties, as important practices and processes take place on national levels in the EU as well. Therefore, three European states that are leaders in NST, Britain, Germany, and the EU nonmember Switzerland, were included in the analysis and subsumed under "Europe."

[9] Within this study a total of 56 interviews were conducted in the US, Britain, Germany, Switzerland, the EU, and the OECD, and were transcribed and analyzed. They focused on the political discourse, regulatory issues of NST, and the specific perspective of the interviewed actors with regard to their organizational and institutional background. Furthermore, 14 experts were questioned on specific issues.

Contextualization

Contextualization is an aspect of social robustness that refers to the relation of governance schemes to external contexts. Questions will focus on the ways governance has been embedded in social, cultural, political, and historic contexts, and their relations with current policy and technology discourses, which include environmental, health, and safety (EHS) issues. A particular focus lies on regulation-oriented schemes and whether they are based on standards, which means that the outcome of the schemes is a clearly defined, comprehensible product such as safety data, or whether the schemes have been based on principles, which form less tangible and substantial commitments. Standards-based schemes yield more comprehensible outcomes and substantial contributions to political, regulatory, and technology discourses.

Another specific focus is on the epistemic basis of deliberation-oriented projects. This leads to examining the conceptual framing of public engagement either in terms of upstream engagement (Wilsdon and Willis 2004) through mutual learning and equally engaging citizens in science and technology-related decision-making processes, or a PUS approach in which the main communicative actors persist in framing an expert-lay divide between science and the public.

Stability

Stability refers to the ways in which governance schemes, projects, and their outcomes are translated into political processes, enforceable, and established to one extent or another in related policies.

Acceptability

Acceptability pertains to analysis of whether governance schemes and projects build in steps or measures to consider the societal acceptability of those schemes and projects, and their methods and outcomes.

Social knowledge

Whether governance schemes and projects have established tools to collect, judge, and build in external societal knowledge is analyzed, as well as whether they have been subject to public consultation or only selected actors have been consulted.

How social knowledge was considered is also analyzed. This involves looking at whether communication was oriented toward education/discussion/ dialogue, or two-way communication and mutual learning. Further communicative or decision-making tools such as voting are also examined.

Evaluation

Finally, frequent testing, feedback, and improvement were analyzed, particularly with regard to whether projects and schemes reflected upon their approaches, methods, and outcomes.

3 The robustness of self-regulation and soft law

Fourteen selected supranational, governmental, private, and international NST regulatory-oriented governance schemes were analyzed. They employed voluntary and informal approaches to regulation by public authorities, supranational or international bodies such as the European Commission and the OECD, and self-regulatory activities by manufacturers, industrial associations and civil society organizations such as environmental and consumer groups (cf. the appendix with Table 3, which describes the aims and results of the approaches, and Table 4, which analyses the approaches regarding the criteria of social robustness). Table 1 presents the final rating of the social robustness of the approaches, which are analyzed in more detail below.

3.1 Social robustness rating

This analysis shows that most of the self-regulatory and soft law approaches only partially meet aspects of social robustness and ideas of a robust science

and technology development. Only a few produced concrete and measurable outcomes.

Contextualization

Most schemes rated high or medium in their contextualization.

Both supranational EU schemes met certain aspects of social robustness. Both are principle-based, which means they declare the intention or invite member states to follow certain, more or less specified principles or ideals in the promotion, research, and development of NST. Both EU schemes are related to currently debated issues such as safety, sustainability, and ethics in research.

Among the governmental schemes, two are reporting schemes that meet criteria of high social robustness. They are based on standards, which lead to defined outcomes such as safety data on manufactured nanoscale materials and risk-related management systems by manufacturers. The other three governmental schemes are based on principles, which makes them less robust, but they address current relevant issues such as risk and stakeholder engagement.

Among the private schemes, the EDF-DuPont Nano Risk Framework, the VCI guidelines, and the Cenarios certification system received the highest ratings because they are standards-based and address risk. The UK Responsible Nano Code is principle-based and applies to organizations involved in all stages of NST development and use. With an overarching aim of a safe and responsible technology life-cycle, the principles and outcomes of the scheme have not so far been specified and remain rather vague. The Swiss Retail Association's code was rated partially robust for its concretely and comprehensively shaped principles and its relationship with current dialogues concerning transparency in consumer information and product safety.

Among the international OECD schemes, the Working Party on Man-

Table 1: Social robustness-rating of regulatory-oriented governance

	Contextualization	Stability	Acceptability	Social knowledge	Evaluation	Sum
Supranational schemes						
EU Action Plan on Nanosciences and Nanotechnologies 2005	0	0	-1	0	1	0
EU Code of Conduct on responsible Nano Research 2007	0	0	-1	-1	1	-1
Governmental schemes						
UK DEFRA Voluntary Reporting Scheme 2006	1	-1	-1	1	0	0
USA EPA Nanomaterial Stewardship Program 2008	1	-1	-1	1	0	0
German NanoCommission/NanoDialogue 2006	0	-1	-1	0	-1	-3
German Nano-Initiative, Action Plan 2006	0	-1	-1	0	-1	-3
Swiss Federal Action Plan "Synthetic Nanomaterials" 2008	0	-1	-1	0	-1	-3
Private schemes						
EDF-DuPont Nano Risk Framework 2007	1	0	-1	1	0	1
UK Responsible Nano Code 2008	-1	-1	-1	-1	-1	-5
German VCI Guidelines 2008	1	-1	-1	0	-1	-2
German/Swiss Cenarios Certification System 2008	1	0	-1	-1	1	0
Swiss Retail Association Code of Conduct Nanotechnologies 2008	0	0	-1	0	0	-1
International schemes						
OECD Working Party on Manufactured Nanomaterials (WMNM) 2006	1	1	-1	-1	0	0
OECD Working Party on Nanotechnology 2007	-1	-1	-1	-1	-1	-5
1 = meets the criterion 0 = partially meets the criterion -1 = doesn't meet the criterion/no specified aspects in this category						

ufactured Nanomaterials received a slightly higher rating with regard to contextualization, even though it is principle-based, because the member states are engaged in a program to test selected nanomaterials according to a comprehensive framework.

Stability

Most schemes received rather low ratings with regard to their outcomes and their translation into political processes and establishment in related policies.

Only one approach received a rating above 0: the OECD Working Party on Manufactured Nanomaterials, which launched two substantial contributions to which member states could show commitment on a voluntary basis. The committed member states were obliged to contribute to a clearly framed and comprehensible program: the sponsorship program for testing of manufactured nanomaterials and the database on research into safety of manufactured nanomaterials. A steering committee was established to observe the proceedings of the working party's projects and their translation into the member countries' political processes.

Nine of the schemes met certain aspects of stability and received a rating of 0. These include the European Union's schemes (which can apply financial pressure on member states and reviews), the U.S. Nanorisk framework, the Swiss Retailers Association's Code of Conduct (which was launched by committed organizations), and the Cenarios Certification System (with intrinsic obligation on certified firms). However, for these scheme's enforceability is still limited to manufacturers voluntarily implementing a certification system.

Governmental action plans consisting of clearly described and verifiable aims, such as the European Union Action Plan, met certain stability criteria with regard to contents and funding for risk research. However, the epistemic basis of an action plan is primarily a declaration of intent only. If the manage-

ment of the objectives remains unspecified, as is the case in the German and Swiss Action Plans, those action plans remain noncommittal and less robust.

Acceptability

None of the analyzed schemes built in any measures to consider its own acceptability or that of the knowledge produced within the scheme. A few schemes mentioned contributing to an increase in the public acceptance of NST, but none received a rating exceeding -1.

Social knowledge

Most of the analyzed approaches considered external and social knowledge to some extent.

Governmental reporting schemes received the highest social knowledge ratings. In addition to the consideration of social knowledge of manufacturers and research organizations, which was the epistemic basis and the core element of the UK and U.S. governmental reporting schemes, the schemes also included external knowledge through consultation with selected actors. The schemes were established in close cooperation with related agencies and included public consultation with feedback possibilities for concerned actors and stakeholders prior to launch.

The EDF-DuPont Nano Risk Framework was also subject to public consultation before its launch in June 2007. In April 2008, EDF and DuPont also organized interactive workshops on nanorisk management in Boston and San Francisco. Contributions from any interested party are encouraged on the scheme's website.

In most cases, social knowledge remained confined to actor knowledge. A few action plans and codes of conduct mentioned the initiation of a dialogue with the general public among their aims. However, none of them made additional statements concerning the way this aim should be implemented. In this respect, these schemes were rated as partially socially robust.

In the European governmental initiatives, each of the three action plans considered knowledge of concerned actors and stakeholders prior to or after its launch. While the EU action plan included the aim of organizing dialogues and collecting comments, the German and the Swiss action plan considered knowledge of concerned actors.

The German NanoDialogue was established based on the intrinsic motivation to consider social knowledge. However, in its case social knowledge was limited to actor and concerned stakeholder knowledge. The final report did not specify to what extent knowledge outside the NanoCommission's members was considered (Catenhusen et al. 2008).

In Switzerland, selected actors and stakeholders of various societal domains contributed to a report on which the action plan was developed.

The private German VCI Guidelines and the Swiss Retailers Association regarded dialogue events with selected actors as a basis for the development of their measures. However, actors were involved and how they were to be selected was not specified on the related websites and in the reports.

None of the international schemes reported any consultation of social knowledge external to the member states' representatives. To what extent the representatives themselves consulted social knowledge was not specified either.

Evaluation

The supranational schemes of the European Union take a leading role in evaluation.

In the action plan and the code of conduct for responsible NST research, biannual reporting of the member states was envisaged. While the action plan described an indicator-based report to the council and the parliament, the code of conduct asks for a review of the recommendation and the extent with which it was adopted and applied within the relevant organizations of the member countries. However, due to the voluntary nature of the code it is even less clear to what extent the member states will really participate in the evaluation process. This proposes the question, to what extent this voluntary code can be translated into the political process.

Among the private initiatives, the Swiss Cenarios Certification System forms the most robust evaluation approach. External evaluation of the establishment of the required processes within the firms applying for certification is an intrinsic condition of a certificate system. Such systems best meet the requirements for social robustness.

The EDF-DuPont Nano Risk Framework takes a leading role in this area as well, as continued external and self-evaluation is planned. Because concrete measures beyond publicly open stakeholder workshops and a call for comments on its website have not yet been further specified, EDF-DuPont evaluation is rated as only partially robust. The same rating was given the Swiss Retailers Association Code of Conduct because it requires self-evaluation by regular member reports on the establishment of the code. Furthermore, the OECD Working Party on Manufactured Nanomaterials established a steering committee to evaluate how its work is proceeding.

3.2 Socially robust strategies? A short summary of the analysis

Supranational and governmental schemes

Among the supranational and governmental schemes, the European Commission's Action Plan and the UK and U.S. reporting schemes received the highest social robustness ratings.

The Action Plan's requirement that member states conduct indicator-based external evaluation seems in particular to be highly robust. External knowledge of selected stakeholders was obtained in dialogues and comments, while a certain enforceability might attach to well described financial aims. However,

the way in which member states report to the council and the parliament on a regular basis, or whether they actually will report at all, is not clear.

The UK and U.S. voluntary reporting schemes were rated highly contextualized due to their standards and risk-relatedness. They considered social knowledge to a high degree and allowed for self-evaluation, but they did not consider their acceptability. Due to their voluntary character, they were only marginally translated into political processes, which turned out to be their weakest aspects. Only a few of the manufacturing organizations voluntarily took the effort to compose and deliver the necessary data. There were 13 data submissions in the UK,[10] 11 from industry and two from academia; 21 companies submitted reports to the U.S. program (U.S. EPA 2009). An assumed high rate of manufacturers not reporting resulted in criticism of the voluntary data reporting approaches in both countries (see e.g. Bergeson 2007, Bullis 2008, Hanson 2008).

Private schemes

While supranational and governmental schemes were rated between 0 and -3, the private schemes showed greater variability. With an overall rating of +1, the EDF-DuPont Nano Risk Framework was socially robust, while at -5 the UK Responsible Nano Code met no robustness criteria at all. The Nano Risk Framework is standards-based, considers risk, and is strong in contextualization and the consideration of external knowledge. Due to its voluntary approach, the commitment of the launching organizations, and its testing and feedback, the scheme rated medium in stability and consideration of social knowledge.

The Cenarios Certification System was rated second-best. Due to its reliance on standards, consideration of

risk, external evaluation and recertification on an annual basis, contextualization and evaluation were rated high. Because evaluation and recertification are built into certification and imply enforceability—at least for the firms applying for or having the certificate—it was rated medium in stability. However, Cenarios does not specify any consideration of social knowledge, nor does it consider its acceptability.

The Swiss Retail Association's code of conduct was rated higher than the two other schemes of private codes or guidelines. This code specified requirements and forces members to adopt the code and conduct evaluation. It intends the establishment of stakeholder dialogue. However, the way in which the results of such dialogue feed forward into the design and content of the code was not specified.

Although the VCI guidelines are clearly specified, they are entirely voluntary and the members are neither under pressure from the Chemical Industries Association to adopt them nor subject to evaluation. However, external knowledge was consulted and considered through stakeholder dialogues.

The UK Responsible Nano Code is the poorest rated private initiative, with low social robustness in each category. The code agreement is principle-based and not binding in any form, not even upon the launching organizations. The principles were rather vaguely shaped, its acceptability is not considered, no social knowledge is consulted, and evaluation is not specified within this code.

International schemes

Among the international schemes, the OECD working parties differed considerably with regard to their social robustness.

The Working Party on Manufactured Nanomaterials (WPMN) is socially robust, particularly because its sponsorship program is based on comprehensible standards and it is sensitive to risk. Further, the WPMN initiated a steering committee that may play a role in

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[10] See <www.defra.gov.uk/environment/ quality/nanotech/policy.htm> (visited 02.11.09).

the political translation of results and in evaluation.

In contrast, the Working Party on Nanotechnology did not demonstrate any social robustness. It specified no evaluation, consideration of social knowledge or program acceptability, translation into the political process, or any contextualization with regard to a concrete product or outcome.

Conclusion

None of the governance measures, soft law and self-regulatory schemes turned out to be socially robust in all aspects. While some schemes showed quite concrete and robust approaches, others are restricted to declarations of intent. Only a few schemes showed robust strategies for consideration of current policy discourses, the enforceability of their outcomes, their translation into the political process, public consultation, and external evaluation, testing and improvement of the scheme. None of the analyzed schemes considered acceptance of its approach, methods, and outcomes.

4 The robustness of deliberation and engagement

"This analysis of public engagement or deliberative-governance projects established in NST draws upon the concepts of participatory technology assessment and upstream engagement." It is based on an earlier study that analyzed six well-documented public engagement projects in selected countries (cf. Kurath and Gisler 2009), which relied upon participant observation (in the Swiss case and the UK Nanodialogue video screening) and a meta-analysis of literature reports and documents (in the other cases).

These public engagement projects included a forum event, the U.S. Nanoscale Informal Science Education (NISE) Network 2005; a citizen jury, the UK Nanojury; dialogues, which include the UK Nanodialogues and the European Union funded Nanologue project; a public event, the UK Bristol Citizen Science

project; and a focus group, the Swiss Publifocus project (cf. Bell et al. 2006, Gavelin et al. 2007, Rey 2006, Singh 2007, Stilgoe 2007, Türk et al. 2006), and Table 5, which describes aim and results of the approaches, and Table 6, which analyses the approaches in terms of the criteria of social robustness. Table 2 presents the social robustness ratings of the approaches, which are analyzed in more detail below.

4.1 Social robustness rating

While the social robustness ratings of the self-regulatory and soft law approaches varied from +1 to -5, the ratings of the engagement projects varied even more, between +3 and -5. In principle, most of the engagement projects partially met certain aspects of social robustness and robust science and technology development; few produced a concrete impact.

Contextualization

Only one project—the UK Nanojury—showed high social robustness. Most met some aspects of social robustness, although two projects showed little or no social robustness.

The UK Nanojury was the only project that was conceptually oriented towards a new framing of communicative actors and overcoming the traditional expert-lay person divide. The main focus of its methodological approach is to break traditional expert-lay frames by giving scientists the roles of witness and audience, and citizens that of jurors.

Apart from the Nanojury, the framing of communicative actors as experts versus lay persons was more or less observable in all other engagement projects despite—as in the UK Nanodialogues and the EU Nanologue—commitments to more mutual-learning-oriented framing by upstream engagement.

The UK Nanodialogues, the Swiss Publifocus, and the EU Nanologue were embedded in, and their products were related to, current policy and technology discourses, mostly focusing on potential

Table 2: Social robustness rating of deliberation-oriented governance

	Contextualization	Stability	Acceptability	Social knowledge	Evaluation	Sum
U.S. NISE Network 2005	-1	-1	-1	-1	0	-4
UK Nanojury 2005	1	0	0	1	1	3
UK Nanodialogues 2006	0,5	1	0	0.5	1	3
UK Citizen Science Bristol 2008	-1	-1	-1	-1	-1	-5
Swiss Publifocus Nanotechnology 2006	0	-1	-1	0	0	-2
EU Nanologue 2005-2006	0	-1	-1	0	0	-2
1 = meets the criterion 0 = partially meets the criterion -1 = doesn't meet the criterion/no specified aspects in this category						

risks and societal issues; their contextualization was therefore partial.

Both of the low-rated projects, the U.S. NISE Network and the UK Citizen Science Bristol project, did not consider risk, safety, public health, or environmental issues. They were framed by a traditional PUS-based notion of educating lay citizens, rather than by engaging knowledgeable citizens in engagement-based dialogue processes.

Stability

Stability received rather weak ratings, with few of the public engagement projects specifying concrete outcomes or translation into political processes. Only the UK Nanojury and Nanodialogues showed robust approaches to producing at least some impact. While the UK Nanodialogues produced collaborative impacts on corporations and foreign aid projects, the Nanojury formulated recommendations to scientists and policymakers. However, to what extent these recommendations were taken up within the relevant organizations and institutions remains unclear; they therefore were rated as only partially stable.

Acceptability

Acceptability received even weaker ratings since only two of the projects—the UK Nanojury and Nanodialogues—considered to any extent the acceptability of their approaches, methods, and the issues discussed. While the Nanojury reflected on the acceptability of the dialogue process in its collaboration with related organizations, the Nanodialogues gave the involved citizens discursive space to reflect on their acceptance of the project. However, the acceptability of both projects was not subject to further consultation. Therefore, they were rated as meeting only certain aspects of acceptability.

Social knowledge

How social knowledge was considered in terms of discussion and communication style, the use of further communicative and decision-making tools, and the inclusion of external societal knowledge, generally showed higher ratings.

Here again, the UK Nanojury and Nanodialogues were rated highest for their use of new and experimental modes of engaging social knowledge, allowing two-way communication in pursuit of the explicit goal of mutual learning, and engaging the public "upstream." While the Nanojury worked in close collaboration with organizations related to its target issues and enabled public issues to be taken up within these organizations, the Nanodialogues opened the discussion by letting citizens discuss an issue

of their own choice and gave them the opportunity to frame the NST-related issues, themes, and questions to be discussed.

The other dialogue-oriented projects, the Swiss Publifocus and the EU Nanologue, mostly framed the themes, issues, and questions around which they aimed at creating a discussion with the participants themselves. This was even more the case with education-oriented approaches such as the U.S. NISE network events and the UK Bristol Citizen Science project. However, the EU Nanologue project gave at least some attention to social knowledge, with greater focus on dialogues and discussion although its approach did not allow much space for breaking up traditional framings of communicative actors regarding their knowledge background, nor did it encourage much mutual learning. This was even more the case with the Swiss Publifocus project. An information brochure (Cerutti 2006) defining NST and explaining potential products, applications, opportunities and risks was handed out to each participant in advance of the meetings; discussion themes and issues were also given in advance. Its focus group meetings then began with two expert presentations explaining potential risks and ethical issues of NST, and the group discussion was moderated.

Evaluation

Most of the projects used frequent testing, feedback, and improvement. By publishing self-reflective evaluation reports, critically assessing approaches, methods, outcomes, and feed-forward into policy processes the UK Nanojury and the Nanodialogues again achieved the highest ratings. The NISE network, the Swiss Publifocus project, and the EU Nanologue project also published their results. However, they did not reflect on their approaches, methods, processes, and their policy process and current societal discourse outcomes (cf. Flagg 2005, Rey, 2006).[11]

4.2 Deficit or upstream model? A short summary of the analysis

The deficit model

With the exception of the UK Nanojury and Nanodialogues, this analysis shows fairly traditional approaches to public engagement that seem to be influenced by the old deficit model of information and education, rather than exchange and mutual learning. Although the methods and approaches were varied, most looked similar to those used in participative programs of the 1990s like citizen conferences, focus groups, or dialogues, whose translation into the political process had certain limitations (Abels and Bora 2004). These projects only partially met criteria of social robustness and none provided any visible evaluation or reflection on method, concept, general aim, or policy impact at the end of the project.

Upstream engagement

However, the UK Nanojury and Nanodialogues seem to have used new and experimental approaches. Located in the UK, where upstream engagement is widely propagated and disseminated, each reached a +3 rather for social robustness. While the methodological approach of the Nanojury reversed the traditional roles of science and the public, and thus supported mutual learning and two-way communication, the Nanodialogues contributed to significant and innovative uptake of citizen's voices by applying public engagement in new contexts such as funding agencies, corporations and foreign aid projects. Both projects were evaluated by reports that suggested improvements by critically reflecting on aims, approaches, methods, process, policy impact, the concept of upstream engagement in general, and public engagement in a broader context of science-society interactions (Stilgoe 2007, Singh 2007, Doubleday and Welland 2005).

Both projects seem to have reached an impressive level of exchange and mutual learning regarding specific projects

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[11] See also <www.nisenet.org/community/groups/forums> and <www.nano-

logue.net> (visited 15.01.2010).

and contexts. Yet, regarding more general science policy questions and decision making in NST, the translation of public engagement into the political process turned out to be more difficult. Even in experimental and new approaches, traditional contrast structures opposing science and the public in terms of an expert/lay divide are difficult to overcome. The Nanodialogues project in particular, maintained a rather traditional framing of science and the public in its conceptualization of experts (nanoresearchers) and a lay public (randomly selected citizens) (see Kearnes et al. 2006b). A videotape documenting the Nanodialogues, in which the public was almost entirely represented by women (concerned mothers) and science by men (informative teachers), further sustained this construction.[12] Such traditional, and particularly gendered framing of the public as a group of randomly selected citizens or lay persons who are pitted against science, represented mainly by classic scientific experts, might not provide ideal ground for more democratic involvement through reflective exchange and mutual learning, which is a core premise of upstream engagement.

5 Accountability and democracy in science and technology governance

Policy discourses on emerging technologies and new scientific fields point to a shift from government to governance. Governance approaches, whether regulatory or deliberation-oriented, have framed responsibility and democracy as desirable aspects of technology development. Governance of this kind has been postulated as a substitute for federal regulation and as a way to more robust science and technology policy.

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[12] The videotape was shown by Prof. Phil Macnaghten at the conference "The risk governance of nanotechnology: recommendations for managing a global issue" on 6th - 7th July 2006 hosted by Swiss Re in Rüschlikon Switzerland.

5.1 Summary of the analysis

Looking at 14 regulatory-oriented and 6 deliberation-oriented governance approaches and projects in NST, this article analyzes the reported increase of social robustness in science and technology policy. None of the 20 governance approaches and projects that were analyzed entirely met all the criteria of social robustness. Only eight had ratings of 0 or greater. Of the 14 soft law and self-regulatory approaches, only one had a social robustness score greater than 0, while five were rated 0. By comparison, two of the 6 engagement projects had social robustness scores of 3, while the rest were rated below 0.

Contextualization

Most of the regulatory and deliberation-oriented governance approaches were well embedded and contextualized in current technology and policy debates, and focused on issues such as potential risks, and environmental and societal issues in NST. Contexts and methods providing engagement played a major role. Even if PUS-based, the highest rated engagement projects used experimental approaches of two-way communication to engage the communicative actors, whether or not expert/lay person framing predominated, in an upstream-engagement-oriented way.

Stability

Stability, which encompasses the ways schemes feed forward into political processes, was nearly the weakest aspect of social robustness. Only one regulatory-oriented and one deliberation-oriented governance scheme established a measure of policymaking and contributed to concrete, measurable outcome. These soft law or self-regulatory approaches are to a certain extent enforceable: they can direct pressure for commitment upon member states or manufacturers. The sponsorship program for testing manufactured nanoscale materials of the OECD Working Party on Manufactured Nanomaterials, requires a binding commitment on

the part of member states to fund and oversee a testing program of selected nanoscale materials, while the UK Nanodialogues contributed new insight to policy discourse in funding agencies, corporations, and foreign aid projects.

Acceptability

None of the regulatory, and only two of the deliberation-oriented schemes reflected on acceptability; it proved the weakest of the five aspects. The UK Nanojury and the Nanodialogues partially met acceptability criteria by affording participating actors a formative role in discussion.

Social knowledge

Most of the governance schemes considered the social knowledge of at least selected actors. Only a few were open to fully public consultation. The regulatory-oriented projects that received the highest scores—the UK and U.S. governmental reporting schemes and the U.S. private Nanorisk Framework—built in tools, methods, and measures to collect and consult social knowledge beyond that of only selected actors. Among the engagement projects, the question primarily focuses not on *whether* public consultation happened, but rather on the *way* social knowledge was considered. However, only two of the six engagement projects received ratings higher than 0. The UK Nanojury and Nanodialogues established equality-oriented engagement that made possible mutual learning and dialogue. The others oriented accounting for social knowledge around education or the provision of acceptance.

Evaluation

Most of the 20 analyzed schemes used frequent testing and at least self-evaluation to assist improvement. Regulatory schemes with external evaluation, testing, and improvement processes collected feedback on websites, held stakeholder consultations and public events, or had built-in external evaluation mechanisms such as certification systems. The supranational EU

schemes also performed well. Among the deliberation-oriented governance measures, evaluation mostly focused on results rather than methods, on approaches, and on critical reflection upon the projects. The UK Nanojury and Nanodialogues, projects with a reflective final report that critically assessed their epistemic basis, approach, methods, and results, performed the best.

5.2 Social robustness

This study shows that only 8 of the 20 analyzed governance schemes met at least some of the social robustness criteria in a concrete, solid way (that is, had ratings equal to or greater than 0). Most turned out to be weak in most aspects of social robustness. Some gave the impression of being confined to declarations of intent, of holding to traditional information and education-oriented engagement based on the old, and widely criticized divide between experts and lay citizens.

For the soft law and self-regulatory initiatives, the lack of robustness arises particularly from their instability with regard to integration into the political process, their lack of consideration of their acceptability, and a deficit of concrete results and enforceable outcomes. They considered little societal knowledge outside that of the proximal actors, organizations, and institutions, and were rarely subject to external evaluation, testing, and improvement.

Regarding the deliberative approaches, several did not go beyond consensus formation or measuring public opinion. Apart from innovative and experimental approaches such as the UK Nanojury and the Nanodialogues, which provide a substantial level of exchange and mutual learning, most projects used fairly traditional methodological approaches that reflect the conceptual framing of the old deficit-model of public understanding of science and related education ideas.

In particular, the notion of a boundary separating science and the public into two societal actors on either side

of an expert/lay divide, and the focus on old contrast structures that further set a unified science and an illiterate public in opposition persist in most of the projects. In addition to this major obstacle to reflective exchange, mutual learning, and more democratic public involvement, the translation of public engagement into the political process and science and technology policy, appears difficult and unclear in most of the analyzed cases. These findings contest the idea that deliberative governance projects and public upstream engagement in NST exemplify a paradigm shift in techno-political discourse and will lead toward the more democratic development of technology that is advocated by proponents of the upstream engagement approach (Wilsdon and Willis, 2004). In fact, governance projects still appear to limit public engagement to values, and social and ethical matters, rather than to expose expertise to scrutiny (Hagendijk and Irwin 2006, 175-176).

5.3 Conclusion

In the governance turn, self-regulation and public engagement have often been framed as substitutes for governmental regulation. In governmental regulation, political responsibility is institutionally based, while in the logics of governance, political responsibility is distributed and deliberated among a variety of actors in different societal domains. As conceived in the governance turn, regulation takes place in a sphere that is, in contrast to governmental regulation, situated outside of democratic control mechanisms. In the case of science and technology governance, techno-political competence is delegated to societal actors who act outside of democratic, legitimized bodies. In NST potential implications are still uncertain. Currently, genuine regulatory and policy issues have been rationalized in terms of governance, which includes ideas such as "good practice," "responsible behavior," and "acceptance building" in self-regulatory approaches and public engagement projects. This could lead to a

decentralization and distribution of political and regulatory responsibility. It is no longer locally bound or identifiable, which as a consequence leads to a depoliticization of regulation (Offe 2008, 71).

As the social robustness analysis of regulatory and deliberation-oriented governance approach shows, the governance turn might not contribute to the intended increase in responsible and democratic science and technology policies. This might be due to the intrinsic weakness by means of political stability, concrete and enforceable outcomes and impacts, and the absence of consideration of social knowledge or at least considering it as an equal, in a mutual-learning-oriented way.

Particularly in NST, in which uncertainty with regard to potentially hazardous implications is predominant, the establishment of politically unstable and socially less robust governance measures appears problematic. This is particularly the case regarding the protection of society and the environment from potential hazards. Therefore, the delegation of techno-political decision-making by political representatives to a variety of societal actors through socially less robust, self-regulatory soft law approaches and engagement projects, might lead to a vacuum in science and technology policy. Such a vacuum might not only impact academic knowledge production in related research fields, but also limit the innovative force of a society.

6 References

Abels, Gabriele/Alfons Bora, 2004: *Demokratische Technikbewertung*. Bielefeld: Transcript Verlag.

Barben, Daniel, 2005: Changing Regimes of Science and Politics: Comparative and Transnational Perspectives for a World in Transition. In: Martin Lengwiler/Dagmar Simon (eds.), *New Governance Arrangements in Science Policy – Discussion Paper of the 'Wissenschaftszentrum Berlin'*, Berlin: 39-63.

Barben, Daniel et al., 2008: Anticipatory Governance of Nanotechnology: Foresight,

Engagement, and Integration. In: Edward J. Hackett/Olga Amsterdamska/Michael Lynch/Judy Wajcman (eds.), *The Handbook of Science and Technology Studies: Third Edition,* Cambridge: MIT Press: 979-1000.

Bell, Christopher L. et al., 2006: *Regulation of Nanoscale Materials under the Toxic Substances Control Act.* Chicago: American Bar Association, Section of Environment, Energy , and Ressources.

Bergeson, Lynn, 2007: Good Governance: Evolution of the Nanoscale Materials Stewardship Program. In: *Nanotechnology Law & Business* Winter 2007: 473–483.

Boekaerts, Monique, 2005: *Handbook of Self-Regulation.* Burlington: Academic Press.

Borràs, Susana/T Conzelmann, 2007: Democracy, Legitimacy and Soft Modes of Governance in the EU: The Empirical Turn. In: *Journal of European Integration* 29 (5): 531-548.

Bullis, Kevin, 2008: EPA's Lousy New Nanotech Program. In: *MIT Technology Review* (January 28, 2008).

Catenhusen, Wolf-Michael et al., 2008: *Verantwortlicher Umgang mit Nanotechnologien Bericht und Empfehlungen der NanoKommission der deutschen Bundesregierung* Berlin: NanoKommission der deutschen Bundesregierung.

CEC, 2004: *Mitteilung der Kommission: Auf dem Weg zu einer europäischen Strategie für Nanotechnologie.* Brussels: Commission of the European Communities (CEC).

---, 2008: *Communication from the Commission: Regulatory Aspects of Nanomaterials* Brussels: Commission of the European Communities (CEC).

Cerutti, Herbert, 2006: *Nano! Nanu? - Informationsbroschüre Publifocus "Nanotechnologien und ihre Bedeutung für Gesundheit und Umwelt".* Bern: Zentrum für Technologiefolgen-Abschätzung, TA Swiss.

CH-Bundesrat, 2008: *Aktionsplan "Synthetische Nanomaterialien": Bericht des Bundesrates vom 9. April 2008.* Bern: Eidgenössisches Departement des Innern, Eidgenössisches Volkswirtschaftsdepartement, Eidgenössisches Departement für Umwelt, Verkehr, Energie und Kommunikation, <www.bafu.admin.ch/publikationen/publikation/00574/index.html?lang=de>.

Doubleday, Robert/Mark Welland, 2005: *NanoJury UK: Reflections from the perspective of the IRC in Nanotechnology and FRONTIERS.* Cambridge: IRC in Nanotechnology, University of Cambridge and FRONTIERS Network of Excellence in Nanotechnology.

Felt, Ulrike et al., 2008: Visions and Versions of Governing Biomedicine: Narratives on Power Structures, Decisionmaking and Public Participation in the Field of Biomedical Technology in the Austrian Context. In: *Social Studies of Science* 38 (2): 233-257.

Flagg, Barbara, 2005: *Nanotechnology and the Public: Part I of Front-End Analysis in Support of Nanoscale Informal Science Education Network.* Arlington, Virginia: Nanoscale Informal Science Education Network, <www.nisenet.org/files_static/evaluation/NISEFrtEndPart1Text.pdf>.

Gaskell, George et al., 2005: Imagining Nanotechnology: Cultural Support for Technological Innovation in Europe and the United States. In: *Public Understanding of Science* 14 (1): 81-90 <pus.sagepub.com/cgi/content/abstract/14/1/81>.

---, 2004: Public Attitudes to Nanotechnology in Europe and the United States. In: *Nature materials* 3 (August 2004): 496.

Gavelin, Karin et al., 2007: *Democratic Technologies? The Final Report of the Nanotechnology Engagement Group (NEG).* London: Involve.

Gibbons, Michael et al., 1994: *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies.* London: Sage.

Gottweis, Herbert/Alan Petersen (eds.), 2008: *Biobanks: Governance in Comparative Perspective.* London: Routledge.

Hagendijk, Rob/Alan Irwin, 2006: Public deliberation and governance: Engaging with science and technology in contemporary Europe. In: *Minerva* 44: 167-184.

Hagendijk, Rob P., 2004: The Public Understanding of Science and Public Participation in Regulated Worlds. In: *Minerva* 42: 41-59.

Hagendijk, Robert P., 2005: *STAGE: Science Technology and Governance in Europe: Challenges of Public Engagement.* Amsterdam: University of Amsterdam, *Final Report.*

Hanson, David, 2008: Regulation: Nanotech Stewardship: Voluntary EPA Program Criticized for not Giving Agency the Data it Needs to Regulate Nanoscale Materials. In: *Chemical & Engineering News* (January 28, 2008).

Irwin, Alan, 2006: The Politics of Talk: Coming to Terms with the "New Scientific Governance". In: *Social Studies of Science* 16 (1): 299-320.

Irwin, Alan/Bryan Wynne, 1996: *Misunderstanding Science? The Public Reconstruction of Science and Technology.* Cambridge: Cambridge University Press.

Jasanoff, Sheila, 2005: *Designs on Nature: Science and Democracy in Europe and the United States.* Princeton: Princeton University Press.

Kaiser, Mario et al. (eds.), 2009: *Assessment Regimes of Technology: Regulation, Deliberation & Identity Politics of Nanotechnology.* Dordrecht: Springer.

Kearnes, Matthew, 2009: The Time of Science: Deliberation and the 'New Governance' of Nanotechnology. In: Mario Kaiser/Monika Kurath/Sabine Maasen/Christoph Rehmann-Sutter (eds.), *Governing Future Technologies: Nanotechnology and the Rise of an Assessment Regime,* Berlin: Springer.

Kearnes, Matthew et al., 2006a: From Bio to Nano: Learning Lessons from the UK Agricultural Biotechnology Controversy. In: *Science as Culture* 15 (4): 291-307.

---, 2006b: *Governing at the Nanoscale. People, policies and emerging technologies.* London: Demos.

Kearnes, Matthew/Arie Rip, 2009: The Emerging Governance Landscape of Nanaotechnology. In: Stefan Gammel/Andreas Lösch/Alfred Nordmann (eds.), *Jenseits von Regulierung: Zum politischen Umgang mit der Nanotechnologie,* Heidelberg: AKA-Verlag

Kearnes, Matthew/Brian Wynne, 2007: On Nanotechnology and Ambivalence: The Politics of Enthusiasm. In: *nanoethics* 1 (2): 131-142.

Kirton, John J./Michael J. Treblicock (eds.), 2004: *Soft Law: Voluntary Standards in Global Trade, Environment and Social Governance.* Burlington: Ashgate.

Kurath, Monika/Priska Gisler, 2009: Informing, Involving or Engaging? Science Communication, in the Ages of Atom-, Bio- and Nanotechnology. In: *Public Understanding of Science* 18 (5).

Kurath, Monika/Sabine Maasen, 2006: Toxicology as a Nanoscience? - Disciplinary Identities Reconsidered. In: *Particle and Fibre Toxicology* 3 (1): 6 <www.particleandfibretoxicology.com/content/3/1/6>.

Lamneck, Siegfried, 1988: *Qualitative Sozialforschung* Weinheim: Psychologie Verlags Union.

Lengwiler, Martin/Dagmar Simon, 2009: *New Governance Arrangements in Science Policy.* Berlin: Wissenschaftszentrum Berlin für Sozialforschung (WZB).

Lösch, Andreas, 2006: Means of Communicating Innovations. A Case Study for the Analysis and Assessment of Nanotechnology's Futuristic Visions. In: *Science, Technology and Innovation Studies* 2: 103-126.

Lösch, Andreas et al., 2008: *Observieren—Sondieren—Regulieren: Zur gesellschaftlichen Einbettung nanotechnologischer Entwicklungsprozesse (Bestandesaufnahme und Modellentwurf).* Darmstadt: Technische Universität Darmstadt, Büro für Interdisziplinäre Nanotechnikforschung—Nanobüro mit Unterstützung des Bundesministeriums für Bildung und Forschung (BMBF).

Maasen, Sabine, 2009: Converging Technologies – Diverging Reflexivities? Intellectual Work in Knowledge-Risk-Media-Audit Societies. In: Mario Kaiser/Monika Kurath/Sabine Maasen/Christoph Rehmann-Sutter (eds.), *Assessment Regimes of Technology: Regulation, Deliberation & Identity Politics of Nanotechnology,* Dordrecht: Springer.

Macoubrie, Jane, 2005: *Informed Public Perceptions of Nanotechnology and Trust in Government.* Washington DC: Woodrow Wlson International Center for Scholars.

Mayntz, Renate, 1996: Politische Steuerung: Aufstieg, Niedergang und Transformation einer Theorie. In: Klaus Beyme/Claus Offe (eds.), *Politische Theorien in der Ära der Transformation,* Opladen: Westdeutscher Verlag: 148-168.

Miller, Peter/Nikolas Rose, 2008: *Governing the Present: Administering Economic, Social and Personal Life.* Weinheim: Wiley.

Nasser, Salem, H., 2008: *Sources and Norms of International Law: A Study on Soft Law.* Glienicke/Berlin: Galda + Wilch.

Nature, 2004: Going public. In: *Nature* 431 (7011 October 2004): 883.

Nowotny, Helga et al., 2001: *Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty.* London: Polity Press.

Offe, Claus, 2008: Governance "Empty Signifier" oder sozialwissenschaftliches Forschungsprogramm? In: Gunnar Folke Schuppert/Michael Zürn (eds.), *Governance in einer sich wandelnden Welt,* Wiesbaden: VS Verlag für Sozialwissenschaften.

Rey, Lucienne, 2006: *Nanotechnologien in der Schweiz: Herausforderungen erkannt: Bericht zum Dialogverfahren publifocus "Nanotechnologien und ihre Bedeutung für Gesundheit und Umwelt".* Bern: Zentrum für Technologiefolgen-Abschätzung, TA Swiss.

Rhodes, Rod A.W., 1997: *Understanding Governance: Policy Networks, Governance, Reflexivity and Accountability.* Buckingham, Philadelphia: Open University Press.

Rip, Arie, 2006: *Folk Theories about Nanotechnology.* Twente: University of Twente.

Rip, Arie/Jan-Peter Voss, 2008: Umbrella Terms in the Governance of Emerging Science and Technology: Bridging the Tension Between Relevance and Scientific Advance. *Governance von Zukunftstechnologien,* Technical University of Berlin, 22.-23. May 2009.

Rose, Nikolas, 1996: Governing "Advanced Liberal Democracies". In: A. Barry/T. Osborne/Nikolas Rose (eds.), *Foucault and Political Reason: Liberalism, Neo-Liberalism and Rationalities of Government,* London: UCL Press.

RS&RAE, 2004: *Nanoscience and Nanotechnlogies: Opportunities and Uncertainties.* London: The Royal Society and the Royal Academy of Engineering,<www.royalsoc.ac.uk/policy>.

Schummer, Joachim, 2009: *Nanotechnologie. Spiele mit Grenzen.* Frankfurt am Main: Suhrkamp.

Singh, Jasber, 2007: *Polluted Waters: The UK Nanojury as Upstream Public Engagement.* Newcastle: Policy, Ethics and Life Sciences Research Centre (PEALS), <www.nanojury.org.uk/pdfs/polluted_waters.pdf>.

Stilgoe, Jack, 2007: *Nanodialogues: Experiments in Public Engagement with Science.* London: Demos.

Türk, Volker et al., 2006: *Nanologue: Opinions on the Ethical, Legal and Social Aspects of Nanotechnologies—Results from a Consultation with Representatives from Research, Business and Civil Society.* <www.nanologue.net/custom/user/Downloads/NanologueWP34FinalPublic.pdf>.

U.S. EPA, 2009: *Nanoscale Materials Stewardship Program: Interim Report.* Washington D.C.: U.S. Environmental Protection Agency: Office of Pollution, Prevention and Toxics, <www.epa.gov/oppt/nano/nmsp-interim-report-final.pdf>.

Weingart, Peter, 2001: *Die Stunde der Wahrheit? Vom Verhältnis der Wissenschaft zu Politik, Wirtschaft und Medien in der Wissensgesellschaft.* Weilerswist: Velbrück Wissenschaft.

Wilsdon, James, 2005: *Small Talk: New Ways of Democratising Science and Technology.* London: Open Democracy, <www.opendemocracy.net/democracy-accountability/science_2871.jsp>.

Wilsdon, James/Rebecca Willis, 2004: *See-Through Science: Why Public Engagement Needs to Move Upstream.* London: DEMOS, <www.demos.co.uk/files/Seethroughsciencefinal.pdf>.

Wullweber, Joscha, 2008: Nanotechnology – An Empty Signifier à Venir? A Delineation of a Techno-Socieo-Economical Innovation Strategy. In: *Science, Technology and Innovation Studies* 4: 27-45.

Wynne, Bryan, 1995: Public Understanding of Science. In: Sheila Jasanoff/Gerald E. Markle/James C. Petersen/Trevor Pinch (eds.), *Handbook of Science and Technology Studies,* Thousand Oaks: Sage: 361-388.

---, 2001: Creating Public Alienation: Expert Cultures of Risk and Ethics on GMO's. In: *Science as Culture* 10 (4): 445-481.

7 Appendix (tables)

Table 3: Description, aim and results of self-regulatory and soft law approaches

Supranational schemes	
European Union (EU), European Commission Action Plan on Nanosciences and Nanotechnologies 2005	Commitment of commission and call to member states for promotion research and development, infrastructure, education, technology transfer, societal dimension, public health, safety and international collaboration in NST. Commitment for concrete actions by the commission such as funding and research focus in 6th framework program. Aim: Integrated and responsible NST strategy for Europe, institutional level of NST discussions. Results: Implementation report and political responses of EU Council and European Parliament.
EU European Commission Code of Conduct on Responsible Nano Research 2007	Voluntary code and recommendation to member states to support public comprehensibility, sustainable, precautionary, inclusive, excellent, innovative, accountable economic, social and environmental development of NST. Aim: to ensure that NST research is undertaken in safe, ethical and effective framework. Results: Conference, EU Commission recommendation and EU Council conclusion.
Governmental schemes	
UK Department for Environment, Food and Rural Affairs (DEFRA) Voluntary Reporting Scheme for Engineered Nanoscale Materials 2006	Voluntary data reporting scheme for industry and research organizations. Aim: government receives information relevant to understanding the potential risks posed by free engineered nanoscale materials. Results: 13 Data submissions according to guideline, annual scheme's progress update reports.
U.S. Environmental Protection Agency (EPA) Nanomaterial Stewardship Program 2008	Voluntary data reporting scheme for manufacturers and processors. Aim: Support agency assembles existing data and information on existing chemical NM; identify and encourage use of risk management practices in developing and commercializing NM; and encourage the development of test data needed, collaborative process with invited stakeholders. Results: Concept paper, TSCA Inventory Status on Nanoscale Substances, 21 data submissions, according to supporting statement and reporting form, public meeting.
German Federal Parliament (Bundestag) NanoCommission/NanoDialogue 2006	Stakeholder commission as central national dialogue committee of the German Government and various interest groups. Stakeholder consisted of representatives from science, industry environmental and consumer organizations, trade unions, government departments and agencies. Aim: analysis of opportunities and risks of NM, under precautionary and sustainable innovations approach. Results: assessment criteria, and basic principles for „responsible" use.
German Federal Government (Bundesregierung) Nano-Initiative, Action Plan 2006	Innovation initiative and action plan of several federal ministries (of education and research (BMBF), work and social issues (BMAS), for the Environment, Nature Conservation and Nuclear Safety (BMU), of Food, Agriculture and Consumer Protection (BMELV), of Defense (BMVg), of Health (BMG), of Economy and Technology (BMWi)). Aim: Technology transfer, political conditions, collaboration among agencies, public dialogue, analysis of environmental and health risks, leading innovations, research-, support- and agency initiatives. Results: Research focus, funding of leading innovations

Swiss Federal Government Action Plan "Synthetic Nanomaterials" 2008	Action plan for risk assessment and management of synthetic nanomaterials, based on basic report: "Risk Assessment and Risk Management of Synthetic Nanomaterials" of the Federal Office of Public Health (FOPH) and the Federal Office for the Environment (FOEN). Aim: a responsible development of nanotechnology, a regulatory framework and public dialogue on its opportunities and risks. Results: National research program on opportunities and risks of nanoscale materials, precautionary framework (Vorsorgeraster) for industrial recognicion of NST specific risks, development of safety framework for NST-related products together with representatives from science, industry, environmental and consumer organizations.
Private schemes	
U.S. Environmental Defense Fund (EDF) – DuPont Nano Risk Framework (NRF) 2007	Standards-based risk management framework scheme for manufacturers Aim: Comprehensive process to evaluate and address potential risks of nanoscale materials for organizations, Results: Scheme consisting six detailed steps for guidance in key questions and risk management practice, commitment to governmental programs (EPA) of applying organizations.
UK Royal Society – Insight Investment – NT Industry Association – NT Knowledge Transfer Network Responsible Nano Code 2008	Principle based code of conduct for organizations involved in the research, production, retail and disposal of products using nanotechnologies. Aim: responsible NST approach throughout the product life-circle. Results: written code with 7 general principles, update and background information.
German Chemical Industries Association (VCI) Guidelines Manuals for a Responsible Handling of Nanoscale Materials 2008	Guideline manuals consisting of core principles such as precaution, product responsibility and workplace safety. Aim: Support for manufacturers and customers for responsible use of nanomaterials, harmonization and use in OECD process. Results: Manuals consisting of checklists, safety sheets, strategy documents, safety research, standardization, stakeholder workshop and risk management guidelines.
German TUV Süd – Swiss Innovation Society Cenarios Certification System 2008	Certifiable risk management and monitoring-system for nanotechnologies. Aim: recognize risks, provide safety, identify, analyze and rate of potential opportunities and risks of NST. Results: certificate for applying firms, annual evaluation and recertification.
Swiss Retail Association Code of Conduct Nanotechnologies 2008	Principle based code on information exchange between manufacturers, suppliers, customer information, risk management and cooperation. Aim: To face increasing importance of nanotechnology in consumer products. Consumer information, transparency between producers, suppliers, retailers and consumers. Results: Factsheet, declaration document for suppliers.
International schemes	
Organization for Economic Co-operation and Development (OECD) Working Party on Manufactured Nanomaterials (MNM) 2006	International cooperation in addressing human health and environmental safety aspects of manufactured nanomaterials. Aim: Safety of manufactured nanomaterials, international cooperation on databases, testing, definition and implementation. Results: sponsorship program for testing of MNM, database on research into safety of MNM, workshops and events.
OECD Working Party on Nanotechnology 2007	International cooperation and consultation on scientific, technical and innovation related questions on responsible nanotechnology development, coordinated analysis in safety issues. Aim: advise upon emerging policy issues of science, technology and innovation related to the responsible development of nanotechnology. Results: review of nanotechnology developments based on indicators and statistics
NT=Nanotechnology, NM=nanoscale materials, MNM=manufactured nanomaterials	

Table 4: Analysis of self-regulatory and soft law approaches regarding the criteria of social robustness

	contextualization	stability	acceptability	social knowledge	evaluation
Supranational schemes					
EU Action Plan on Nanosciences and Nanotechnologies 2005	Principle-based, R&D, risk and social issues related	Declaration of intent, partly enforceably by financial pressure on member states	Not specified	Indirect by dialogues and comments	Bi-annual report to council and parliament based on indicators
EU Code of Conduct on responsible Nano Research 2007	Principle-based, research-related	Invitation to member states, voluntary, but partly enforceable by bi-annual reviews	Not specified	Not specified	Bi-annual review recommendation and extent of adoption and applicance
Governmental schemes					
UK DEFRA Voluntary Reporting Scheme for Engineered Nanoscale Materials 2006	Standards-based, risk-related	Voluntary call, non-enforceable	Not specified	Subject to public consultation	Annual self-evaluatory review
U.S. EPA Nanomaterial Stewardship Program 2008	Standards-based, risk-related	Voluntary call, non-enforceable	Not specified	Subject to public consultation	Self-evaluation
German NanoCommission/NanoDialogue 2006	Principle-based, risk- & dialogue-related	Recommendation, voluntary principles non enforceable	Not specified	Knowledge of involved actors	Not specified
German Nano-Initiative, Action Plan 2006	Principle-based, R&D & risk-related	Declaration of intent, non enforceable	Not specified	Indirect by involved actors	Not specified
Swiss Action Plan Synthetic Nanomaterials 2008	Principle-based, risk-related	Declaration of intent, non enforceable	Not specified	Consultation of selected actors	Not specified
Private schemes					
U.S. Nano Risk Framework 2007	Standards-based, risk-related	Voluntary agreement, partly enforceable on launching organization	Not specified	Public consultation, international	Continued self-and external evaluation planned
UK Responsible Nano Code 2008	Principle-based, organization-related	Voluntary agreement, non enforceable	Not specified	Not specified	Not specified
German VCI Guidelines 2008	Standards-based, risk-related	Voluntary agreement, non enforceable	Not specified	Discussion with actors	Not specified
German/Swiss Cenarios Certification System 2008	Standards-based, risk-related	Enforceable for certified firms	Not specified	Not specified	Annual evaluation and re-certification
Swiss Retail Association Code of Conduct Nanotechnologies 2008	Principle-based, dialogue-related	Voluntary agreement, members required to report	Not specified	Stakeholder dialogue	Self-evaluation by member reports
International schemes					
OECD Working Party on Manufactured Nanomaterials 2006	Standards-based, risk-related	Commitment of member states to sponsorship program and database	Not specified	Not specified	Not specified, evaluation possible by steering committee
OECD Working Party on Nanotechnology 2007	Principle-based, R&D innovation-related	Not specified	Not specified	Not specified	Not specified

Table 5: Description, aim and results of public engagement projects

U.S. Science Museums Nanoscale Informal Science Education (NISE Network) 2005	A series of forum events lasting 2-3 hours, involved presentations by scientific experts and small group discussions, attended by 30-50 participants (mainly science museum visitors), organized by a nationwide collaboration of five science museums, universities, research institutions, artists. Aim: engage the public in the emerging NST field. Results: Forum event discussions.
UK Greenpeace - The Guardian - Interdisciplinary Research Collaboration (IRC) in Nanotechnology, University of Cambridge - Policy, Ethics and Life Sciences Research Centre (PEALS), Newcastle University Nanojury 2005	Two-way citizens' jury, traditional method enriched with multi-stakeholder oversight: of science advisory panel, and built-in control mechanism allowing jurors address topic of their choice before turning to NST. Aim: non-specialist perspective on NST science policy and environmental and public health issues, recommendations by jurors for nanotechnology's future development in UK. Results: promise of response from Department for Business, Enterprise and Regulatory Reform.
UK Think Tank DEMOS - Lancaster University Nanodialogues 2006	Four small-scale experiments in upstream public engagement, inquiry, dialogue, workshop, focus group, experience, experimental approach and a mix of adapted dialogue methods such as people's inquiry (three deliberative workshops with east London residents and input from scientists, environmental agency staff, policymakers, and other stakeholders); deliberative dialogue involving scientists, research-council staff, and members of the public; a workshop involving policymakers, politicians, and representatives from two communities; and a series of focus groups discussing scenarios developed by DEMOS and a commercial manufacturer. Aim: public engagement in decision making of research direction. Results: Set of recommendations and presentation to DEFRA and research councils.
UK University of Bristol Citizen Science Bristol 2008	Science-communicaton, activities consisting of chat show-style debates, website resources, online games, and teachers' materials. Aim: engaging young people (mostly students) in discussions about the role of science and technology in society. Results: Vote on areas of NST research to be founded and the degree of NST regulation.
TA Swiss – Federal Office of Public Health (FOPH) – Federal Office for the Environment (FOEN)- Zurich University of Applied Sciences Publifocus Nanotechnology, Health and the Environment 2006	Focus group meetings with randomly selected citizens/members of the public in 4 lingual regions of Switzerland, one with concerned actors. Use of traditional method of focus group meetings citizens discussed a topic set by organizers, participants received a brochure defining NST in advance, and meetings were introduced by expert presentations from a toxicologist and an ethicist. Aim: Finding out about public acceptance, opinions and questions on nanotechnology and public view on potential social and economic implications. Results: Final report for public and parliament.
EU 6th framework programme: German Wupppertal Institute – Swiss Federal Laboratories for Materials Testing and Research (EMPA) – UK Forum for the Future and pan-European Triple Innova Nanologue 2005-2006	Research project with dialogue part, using methods of public consultation and stakeholder-dialogues involving business, science, and civil society organizations. Aim: help establish common understanding on social, ethical and legal aspects of nanotechnology applications and facilitate Europe-wide dialogue among science, business and civil society about benefits and potential impacts. Results: web-based tool (the NanoMeter), scenario report, presentations, and articles.

Table 6: Analysis of public engagement projects regarding the criteria of social robustness

	contextualization	stability	acceptability	social knowledge	evaluation
U.S. NISE Network 2005	PUS-based, research, development and trade-related, expert/ layperson framing	Not specified	Not specified	Education-oriented, expert teaching, expert-lay citizens discussion	Not specified, reports on public opinion and communication
UK Nanojury 2005	Engagement-based, risk-, and societal issues-related, equally-oriented framing of communicative actors	Recommendations to scientists, policy-makers, journalists	Methodological acceptability of participants	Mutual-learning-oriented, two-way communication,	Report, articles, meta reflection on project, design, methods
UK Nanodialogues 2006	Engagement-based, risk-, research-, policy- and societal issues-related, slight orientation to expert/ layperson framing	Impact in corporations, foreign aid, research councils	Methodological acceptability of participants	Mutual-learning-oriented, discussion, dialogue	Reports from each experiment, articles, pamphlet, meta-reflection on project, design, methods
UK Citizen Science Bristol 2008	PUS-based, research and development-related, expert/ layperson framing	Not specified	Not specified	Education-oriented, discussion, vote	Not specified
Swiss Publifocus Nanotechnology 2006	Engagement-based, risk-related, expert/layperson- framing	Not specified	Not specified	Dialogue-oriented, discussion, teaching, vote	Report, no meta-reflection on project, design, methods
EU Nanologue 2005-2006	Engagement-based, risk-related, expert/layperson- framing	Not specified	Not specified	Dialogue-oriented, discussion	Report, no meta-reflection on project, design, methods
Public engagement projects	contextualization	stability	acceptability	consideration of social knowledge	evaluation
U.S. NISE Network 2005	PUS-based, research, development and trade-related, expert/ layperson framing	Not specified	Not specified	Education-oriented, expert teaching, expert-lay citizens discussion	Not specified, reports on public opinion and communication
UK Nanojury 2005	Engagement-based, risk-, and societal issues-related, equally-oriented framing of communicative actors	Recommendations to scientists, policy-makers, journalists	Methodological acceptability of participants	Mutual-learning-oriented, two-way communication,	Report, articles, meta reflection on project, design, methods
UK Nanodialogues 2006	Engagement-based, risk-, research-, policy- and societal issues-related, slight orientation to expert/layperson framing	Impact in corporations, foreign aid, research councils	Methodological acceptability of participants	Mutual-learning-oriented, discussion, dialogue	Reports from each experiment, articles, pamphlet, meta-reflection on project, design, methods
UK Citizen Science Bristol 2008	PUS-based, research and development-related, expert/ layperson framing	Not specified	Not specified	Education-oriented, discussion, vote	Not specified
Swiss Publifocus Nanotechnology 2006	Engagement-based, risk-related, expert/layperson- framing	Not specified	Not specified	Dialogue-oriented, discussion, teaching, vote	Report, no meta-reflection on project, design, methods
EU Nanologue 2005-2006	Engagement-based, risk-related, expert/layperson- framing	Not specified	Not specified	Dialogue-oriented, discussion	Report, no meta-reflection on project, design, methods