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Nanotechnology – An Empty Signifier *à venir*? A Delineation of a Techno-socio-economical Innovation Strategy

Joscha Wullweber (University of Kassel)

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Abstract

The aim of this article is twofold: First, I would like to theoretically contribute to Science and Technology Studies, and to *Science, Technology and Innovation Studies*, respectively, by introducing a *hegemony- and discourse-theoretical inspired political economy* as an interdisciplinary approach. And second, I shall present some tentative empirical analyses of the policy field of nanotechnology.

Nanotechnology is widely perceived as *the* key technology of the 21st century. As a result, it is becoming increasingly important in many government policies devoted to technology. Nanotechnology is supposedly appealing for many actors, since it is expected to both produce entirely new materials and revolutionize production processes in virtually all industrial branches. Approaching the 'nano-hype' from a discourse-theoretical perspective, I shall show that nanotechnology is not a definite technology, but an *empty signifier*. This empty signifier provides the basis for an encompassing socio-economic project that is kept together only by the signifier itself. This "innovation project" creates a link between nanotechnology and the future of the industrialised states. It aims, above others, at their reconstruction along competitive criteria as 'competition states'. Hence, I shall locate nanotechnology policies within a discursive field of political and economic interests and strategies.

My theoretical approach highlights the importance of hegemonic struggles for the construction of (political) reality. Hegemonic practices shape the discursive structure, which, in turn provides the strategic-selective conditions for articulation. Accordingly, policymaking can be described as a rather performative process, which uses complex systems of representation to establish a situation of stability and predictability. Hence, the governance of nanotechnology has to be understood as a contradictory battleground, where certain actors try to enforce their interests.

"Imagine a single area of scientific discovery with the potential to enable a wealth of innovative new technologies across a vast array of fields including healthcare, information technology, energy production and utilization, homeland security and national defence, biotechnology, food and agriculture, aerospace, manufacturing, and environmental improvement. Nanoscience (...) has this potential" (National Science and Technology Council et al. 2003).

"the world is about to be rebuilt (...) from the atom up. That means tens of trillions of dollars to be spent on everything (...) are all about to undergo profound and fundamental change. And as a result, so will the socio and economic structure of the world. Nanotechnology will shake up just about every business on the planet" (Josh Wolfe, quoted in ETC 2005a: 24).

1 Introduction

Nanotechnology is perceived as the "future technology" (e.g. Wood 2003), the "key technology" (c.f. Royal Society/ Royal Academy of Engineering 2004), and "the defining technology for the 21st century" (c.f. European Commission 2004a). The "nanotech-revolution" (c.f. ETC 2005b) is declared to have profound economic, ecological and social impacts on almost all societies, since it is expected to both produce entirely new materials and revolutionize production processes in virtually all industrial branches. As a result, this technology becomes increasingly important in many government technology policies. Since the Apollo moon programme, no scientific research endeavour has received more public funding than nanotechnology. Apparently, the "biotech century" – which according to Rifkin (1998: 1) entailed "a technology revolution unmatched in all history in its power to remake ourselves, our institutions, and our world" – has been surpassed by the "nanotech century" today.

A new and powerful technology emerges these days. But instead of taking this technological development as an inevitable and quasi-natural process, this article investigates the construction of the nanotechnology policy field and conceptualizes the governance of technologies as a contradictory ground of struggles. The aim is to disentangle the nanotechnology hype and to locate nanotechnology policies within a discursive field of political and economic interests and strategies. Approaching the "nano-hype" from a hegemony- and discourse-theoretical perspective, the argumentation shall show that nanotechnology is not a definite technology, but an empty signifier and a political project that serves certain interests and strategies. It will be argued that nanotechnology acts as a kind of "carrier force" - as a techno-socio-political innovation strategy - for economic expansion. In addition it serves for the reconstruction of the industrialised states along competitive criteria, especially in the advanced industrialised countries. However, technological development depends heavily on its public acceptance. Affected by the negative public perception of genetically modified food, governments pursue different strategies to gain approval for nanotechnology. This article focuses on articulations and narratives – stories that create meaning and orientation and form views – which constitute the policy field of nanotechnology and become hegemonic in regulation and governance of nanotechnology. One of the main analytical contributions to the current analyses of nanotechnology is to disentangle some strategies and interests important to understand nanotechnology. This should help to advance a socio-political analysis of nanotechnology, which in current studies is still underemphasised.

2 Nanotech inside?

Current analyses of nanotechnology within *Science and Technology Studies* (e.g. Glimell/ Fogelberg 2003a; Baird/ Schummer 2004, 2005; Baird/ Nordmann/ Schummer 2004a; Nordmann et al. 2006; Schummer/ Baird 2006) struggle with the very definition of the term itself. Obviously, the definition of nanotechnology is controversially debated (cf. Paschen 2003: 38; Decker/ Fiedeler/ Fleischer 2004: 10; Bundesamt für Sicherheit in der Informationstechnik 2007: 15). In fact, it has thus far proven impossible to even agree on the appropriateness of the term nanotechnology: "[A]s the term 'nanotechnology' encompasses such a wide range of tools, techniques and potential applications, we have found it more appropriate to refer to 'nanotechnologies'" (Royal Society/ Royal Academy of Engineering 2004: 5), which is defined as follows: "*Nanotechnologies* are the design, characterisation, production and application of structures, devices and systems by controlling shape and size at nanometre scale" (ibid.; italics in original). Accordingly, nanotechnologies have to be distinguished from "Nanosciences", "[a]lthough there is no sharp distinction between them" (ibid.): "*Nanoscience* is the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a larger scale" (ibid.; italics in original).

Most definitions of nanotechnology refer to the nanoscale, which (usually) varies between 1-100 nanometres (10^{-9} to 10^{-7} metre): "A broad (...) definition might be the area of science and technology that is currently evolving at the nano-scale" (Sweet/ Strohm 2006: 528-529). Glimell and Fogelberg (2003b) privilege such a definition as well: "*Nanotechnology is everything that occupies the scale of the nanometer. [...] A n*anometer technology then naturally deals with the issue of how to control these molecules, atoms, and electrons, and about how this technology might be mass produced" (Glimell/Fogelberg 2003b: 19-20; italics in original). But, even the scale is under debate: "The most liberal view of nanotechnology encompasses all technology that operates below the threshold of 1,000 nanometres, or one micron" (Feder 2004: 1). However, Schummer rejects this definition: "Since it applies ubiquitously, the nanometer scale is insufficient to define any particular or new kind of research" (Schummer 2004a: 16). The most restricted definitions are those, which refer to molecular manufacturing: According to this, nanotechnology is "the ability to understand, control, and manipulate matter at the level of individual atoms and molecules, as well as at the ‚supramolecular' level, involving clusters of molecules. Its goal is to create materials, devices, and systems with essentially new properties and functions because of their small structure" (Roco 2004: 890).

Some researchers are surprised at these varying types of approaches to nanotechnology: "Given this tempest of activity, it seems unusual that a common and precise definition of "nanotechnology" is difficult to come by" (Sweet/ Strohm 2006: 528). Others claim the need for a commonly accepted definition: "In order to have meaningful discourse on the societal impact of nanotechnology, we must first agree on what we mean by nanotechnology" (Theis 2001: 60).

Hence, the question is why nanotechnology is that difficult to define. Some scholars think this difficulty arises from the fact that many researchers just use the label to apply for research grants (e.g. Stix 2001: 32; Glimell 2003: 71; Parr 2003: 6; Khushf 2004: 33-34). Others argue that it is the very "character" of nanotechnology as an "umbrella-" or "enabling technology" (e.g. Fogelberg 2003: 42; Paschen 2003: 39). Moreover, for some scholars nanotechnology represents a culture-historical phenomenon (e.g. Baird/ Nordmann/ Schummer 2004b:

6; Schiemann 2006). In this article it will be argued that the above-mentioned reasons are not entirely mistaken, but they still do not capture the main issue, which is at stake.

The aim to analyse the discursive field of nanotechnology is based on the assumption that the definition of what nanotechnology entails is controversially debated. Historically, the physicist Richard Feynman is seen as the theoretical founder of nanotechnology. In his famous speech "There's plenty of room at the bottom" (Feynman 1959), Feynman developed the conceptual underpinnings of the possibility to examine, control, and manipulate matter at the scale of individual atoms and molecules without using the term nanotechnology. However, there are signs that Feynman was created retrospectively as the founder of nanotechnology (c.f. Toumey 2005; Nordmann 2007). The term "nanotechnology" was first used by Norio Taniguchi, referring to the capacity of precisely engineering materials on the nanometre scale (c.f. Taniguchi 1974). A breakthrough for nanotechnology was the research on the scanning tunnel microscope (STM) by Gerd Binnig and Heinrich Rohrer in 1981. While at the beginning it was only used to visualise molecular structures, scientists soon discovered that this instrument was also applicable to move molecules and atoms. In 1990, Don Eigler and Erhard Schweizer from IBM used a STM to move 35 xenon atoms (one at a time!) to write their company logo. But it was probably Eric Drexler, who popularised the term (c.f. Drexler 1986; Drexler/ Peterson/ Pergamit 1991; see below). Starting in the late 1980s, the term was used by more and more people, describing very different applications, processes, and fields of research. Interestingly, Drexler himself had a very narrow definition, defining nanotechnology as the "development of nanomachines able to build nanomachines and other products with atom-by-atom control (a process termed *molecular manufacturing)*" (Drexler 2004: 21; italics in original). This narrow framing was broadened step by step to the point where it became completely blurred: "Apart from a characteristic size scale, it is difficult to find commonalities" (Royal Society/ Royal Academy of Engineering 2004: 5). I argue that the power of nanotechnology is partly due to its elusive character. Nanotechnology is not a definite technology, but an "empty signifier" (see below).

The term nanotechnology encompasses fields like nanomaterials, nanoelectronics and optoelectronics, bio-nanotechnology (incl. nanofood), nanomedicine, cosmetics and applications of information and communication technologies. Many applications and products labelled as *nano* are already available on the market. Others will probably be available in the near future (5-10 years) and some may never (or only in the far future) become reality. Only a few examples will be mentioned, in order to give an idea where the term nanotechnology is applied today. The first nanotech-labelled products appeared in the semiconductor industry to increase storage densities on microchips and in the pharmaceutical industry to improve drug targeting and diagnostic aids. The bulk of today's applications lies in the sphere of so-called nanoparticles (like "buckyballs" and "nanotubes"). Nanoparticles are said to be able to contribute to stronger, lighter, cleaner and "smarter" surfaces and systems. Therefore, nanotechnology is still not creating entirely new products but plays its part in the enhancement of already existing products. "Nanoparticles" are used in a wide range of "new" products: for example in the form of Titan dioxide and Zinc oxide to provide UV protection in sun creams; in the manufacture of scratchproof glasses; in lacquers and paints to provide better protection of surfaces against scratching, soiling or algae coverage; and in ceramic coatings for stronger solar cells.

Drawing on post-structuralist approaches, nanotechnology is conceptualised in this article as an empty signi-

fier.[1] An empty signifier is a signifier that has become detached from its previous particular content. Through (strategic) articulations this signifier tends to loose its particularity in order to become the name of fullness – a universality. Thus, an empty signifier is a hybrid of a particularity and a universality. This means, "that the signifier which is emptied in order to assume the representing function will always be constitutively inadequate" (Laclau 1996: 40). The empty signifier will always be a universality contaminated by a particularity, i.e. a *tendentially empty signifier* – an empty signifier *à venir* (cf. Laclau 2000: 304; Derrida 1999: 184).

The signifier nanotechnology denotes a universal technology that is able to solve the world's most pressing problems: The provision of clean water worldwide, the satisfaction of global energy needs (with "clean" solutions), the maximisation of agricultural productivity, the creation of new jobs etc. Hence, nanotechnology can be seen as a techno-socio-economical innovation strategy – a strategy that offers a technological solution for socio-political problems. While Norio Taniguchi or, more probably, Eric Drexler coined the term, referring to the capability to precisely engineer materials on the nanometre scale, the term became more and more detached from that meaning – it became *tendentially empty*. By emptying the signifier from its "original" meaning it was possible to refill the term with different contents and associate it with other positive connotations, such as the "next industrial revolution", (economic) wealth, sustainable development and knowledge-based society. Therefore, an empty signifier emerges in the hegemonic process of signification. At the same time, it retroactively acts upon the system it denotes, establishing a previously nonexistent field. Societal forces struggle to launch such signifiers and to fill their content hegemonically: "Society generates a whole vocabulary of empty signifiers whose temporary signifieds are the result of a political competition" (Laclau 1996: 35). And to "hegemonize something is exactly to carry out this filling function" (ibid: 44).

The empty signifier nanotechnology is intimately connected with the emerging narrative of the nanotechnology industry and the fantastic expectations surrounding the nanotechnology market. They all construct the narrative of a technology that will bring wealth to the people and could serve as a competitive advantage in the global struggle for market shares. In almost all advanced industrialised states, scientists and politicians emphasise the myriad of possible applications and marvellous benefits that will significantly change society. The advocates of nanotechnology "need" the broadness of the definition in order to construct a coherent narrative from very different sources. Up to a certain point, other technologies like biotechnology or genetic engineering could as well be described as empty signifiers, since they all invoke(d) a certain universality in bringing solutions to pressing societal problems. The salient and analytically interesting point in describing nanotechnology as an empty signifier is twofold: first, it is possible for different actors to use the term nanotechnology strategically for different purposes, since the term is very broad.[2] Second, it inaugurates a perspective in which nanotechnology is perceived as a political project. Thus, the governance of nanotechnology becomes a vibrant terrain, criss-crossed by hegemonic struggles. Hence, the analytical contribution at hand is first and foremost aiming at the deconstruction of some strategies and interests behind that "technology". In addition it tries to advance a socio-political analysis of nanotechnology.

[1] Huber (2007: 5) brought forward a similar argument.

[2] I would argue the term is slightly broader than e.g. biotechnology.

To conclude this chapter, the guiding thesis is: nanotechnology is neither a definite technology or method, nor an array of applications or a research field. It rather has to be understood as an encompassing political project or, more precisely, as different political projects that are kept together only by the empty signifier itself. To designate nanotechnology as a political project does by no means suggest that no fundamental technological changes take place nor that this project will not have "real" and "tangible" implications for (wo)men and society. Nanotechnology, as an ensemble of different technologies *and* as a political project, is likely to have the potential to radically change the material livelihoods of many people (cf. Wullweber 2006: 106-112). Simultaneously, there is no *one coherent strategy* of a certain group guiding the nanotech project. Quite contrary, there are different interests and, to some extent, conflicting strategies competing. In order to be able to fully develop this argument, the theoretical tools guiding the research shall be delineated in the following.

3 Discourse, hegemony and political economy

The theoretical approach is committed to a discourse-theoretical ontology, which entails an understanding of systems of signification and subjectivity as importantly constitutive for social reality. Furthermore, the struggle for (political) hegemony is seen as a key feature of liberal and pluralistic democracies, and defines the very terrain in which a political relation is constituted. Finally, the approach draws on the heterodox economy. This is to integrate a middle-range theory, which is able to capture the importance of capital accumulation and modes of economic regulation for the analysis of capitalist societies in general, and for the analysis of nanotechnology policies in particular.

3.1 Discourse theory

Post-structuralist authors have emphasised the role of discourse as constitutive for politics.[3] A discourse can be described as the sum of all verbal and non-verbal articulations on a particular topic, shaping the perception, thinking, and action of individuals. Within this conception of discourse, language, action and meaning are closely connected: "Meaning is learned from, and shaped in, instances of use; (...) so meaning is very much the product of pragmatics" (Pitkin 1972: 84). Articulation is understood as a "practice establishing relations among elements such that their identity is modified as a result of the articulatory practice" (Laclau/ Mouffe 1985: 105). Thus, a discourse is a structure – more precisely an entity – which has a significance in a social, economic, or political context. It can be seen as a relational ensemble of signifying sequences, which together constitute a more or less coherent framework of what can be said or done. But discourses are not simply reflections of these contexts. They rather are complex mediations between various codes, which assign possible meaning to reality (c.f. Gottweis 1998: 31-34). Furthermore, a discourse fails to invoke a complete closure, since there is always something escaping the infinite processes of signification - an irreducible "surplus of meaning" (Laclau/ Mouffe 1985: 111).

Post-structuralist approaches highlight the importance of discourse for the construction of (political) reality. They highlight the constructed nature of actors in politics and society, and the phenomenon of competing, conflicting, and often contradictory structures of meaning and expression in social and political life. The pre-discursive meaning of entities such as institutions, subjects of policymaking, and political identities is denied. This is due to the reasoning that the notion of a "reality"

[3] Sometimes also called "postconstructivism" (cf. Wehling 2006).

with a fixed and pre-discursive meaning fails to recognise the analytical difference between "being" (lat. esse) and "existence" (lat. ens). The (physical) "existence" of objects is not dependent on their discursive articulation, i.e. existence extraneous to any meaning. But the "being" of objects (their meaning) depends on their articulation within discourses. Accordingly, there is no *meaningful* "reality" outside the field of discursivity. But the "discursive character of an object does not, by any means, imply putting its existence into question" (Laclau/ Mouffe 1990: 82, cf. 103).

The "truth" of an event will always be the contingent outcome of struggles among competing discourses and narratives, transforming "what is out there" into a socially and politically relevant concept. The outcome of these struggles is contingent, insofar as no actor can anticipate the exact results of his or her action. However, the "scope of possibilities" to determine a discourse differs much among the actors. Strategic articulations are an important part of discourses and can be understood as an attempt to establish a chain of equivalence between different discursive elements. According to Gottweis (c.f. 1998: 31-34), successful articulations bring elements of stability and order into what is part of the available repertoire of political visions and identifications in one's social situation. They are modes to organise political, scientific, and economic reality. Therefore, an articulation is a material and strategic practice that "inscribes itself into the texture of the social and creates or rewrites order by drawing from a manifold of discursively available narratives and modes of representations" (ibid.: 333). But, it is vital to stress the fact that "structures rarely have a simple, unequivocal relation to a single strategy" (Jessop/ Sum 2006: 66). By introducing the neologism "discourse-organisation", the argumentation intends to characterise a relatively stabilised spatio-temporal, socio-political and strategic-selective structure of a specific society, including general concepts and values of social order. Fordism or neo-liberalism, for example, can be described as forms of discourse-organisation. A discourse-organisation is a stabilised set of discourses, where meaning does not float freely anymore but is fixed to a great extent. Thus, the horizon of possibilities is limited.

A post-structuralist theorising of nanotechnology puts emphasis on power struggles and interests, and also takes into account contingent-accidental events as constitutive for technological development. It criticises the notion that technological development is an inevitable and automatic progress of science as well as the assumed progressive character of scientific development. In post-structuralist rendering neither the "truth" of nanotechnology as the technology of the 21st century nor the policy problem "nanotechnological risks" or the "high-technology gap" are simply existent. Rather, the question is what constitutes a "high-technology", whose interest does this kind of framing serve, and what social forces try to articulate such tropes. Thus, science and power are conceptualised as two strongly interconnected phenomena, and the a priori existence of stable boundaries between economy, politics and science is questioned.

3.2 Hegemony

The question is, whether certain articulations within the nanotechnology discourse are able to become hegemonic. Hegemonic in the sense that nanotechnology becomes widely accepted as a technology producing wealth for the society. The conception of hegemony used in this article derives from Gramsci's approach. For Gramsci hegemony means the ability of the ruling groups to pursue their interests in such ways, that the "ruled" groups regard these interests as common or general interests. Hegemony is perceived as an active consent of the ruled (c.f. Gramsci 1971: 180-182). (Neo-)Gramscian ap-

proaches introduce a concept of power that primarily rests on the ability to universalise the particular interests of a group as a socio-economic and political structure. A certain group is hegemonic, and not only dominant, if it succeeds to win approval of its authority among members of other societal groups. The "ruling groups" have to be responsive, at least to a certain degree, to the respective interests of other groups. Identity of interests can be achieved by taking into account the interests of other groups in the formative processes of institutionalization. These interests have to be merged, so that they become equated with the very institutions (c.f. Cox 1996: 99-100).

From a post-structuralist point of view, the concepts of discourse and hegemony are inextricably linked and mutually conditioned. Hegemonic practice shapes discourse, which in turn provides the conditions of possibility for hegemonic articulation (c.f. Mouffe 1979: 179). Framed like this, hegemony is a type of social relation. It can be described as the widening of a particular discourse – in the form of a socio-political project – towards a certain horizon of social orientation and action, i.e. a discourse-organisation, through the articulation of unfixed elements into partially fixed moments. The ambit and the horizon of a particular discourse-organisation are constituted by the exclusion of competing discursive elements ("social antagonisms"). The exclusion of alternative articulations into a discursive "exteriority" is the substantial element of hegemonic practices of articulation. The organisation of a hegemonic discourse depends on its coherence to provide a surface of inscriptions for a wide range of wants, meanings, interests, and beliefs. "The fact, that one discursive formation gains influence over another, that it becomes *hegemonic*, is related to the degree of congruence and complementarity that this discursive formation has within a given discursive constellation" (Gottweis 1998: 36; italics in original).

To be successful, i.e. to become hegemonic, a socio-political project has to be articulated in relation to the (imaginary) common good. Since the common good only exists as an imaginary common good, and hence as an empty place, there are only particular interests, which try to occupy this empty space through strategic articulations (cf. Jessop 2007: 11). Thus, a hegemonic project has to be articulated in a specific way: In these processes of articulation a multiplicity of subjects, actors, and relevant forces do not only act on the assumption that the implementation of the project is a prerequisite to achieve the common good, but adopt precise positions, which are provided through the hegemonic project. Three general requirements have to be achieved in this regard: First, there is the need for an empty signifier, since every socio-political project requires a signifier, as a medium of representation. And, as stated above, an empty signifier "unifies a given field, constitutes its identity: it is, so to speak, the word to which 'things' themselves refer to recognize themselves in their unity" (Žižek 1989: 95-96). Secondly, the empty signifier has to have a positive connotation within the discourse in question. It has to hold a privileged relation vis-à-vis the common good. At the same time, alternatives to the hegemonic project have to be presented as unimaginable and unrealizable. And thirdly, the discourse promoted by the hegemonic project has to be relevant for society. Hence, the analysis of the hegemonic discourse-organisation and the analysis of the overall socio-political context is essential for the evaluation of a hegemonic project.

3.3 The "competition state"

Many studies have explored the alterations of the state in the era of globalisation. Almost all analyses share the notion that the form and structure of the state changed since the 1970s (e.g. Lipietz 1987; Wood 1997; Jessop 2007). In this context, the notion of the internationalisation of the state

refers to different and often contradictory policy answers within the state apparatuses to handle this new situation. It will be argued, that the hegemonic discourse to reconstruct the state in the advanced industrialised countries is one, that emphasises a state that has to become streamlined along competitive criteria; and that nanotechnology plays an important role in supporting this discourse.

Jessop (c.f. 1990) emphasises that the state is not a pre-given structure but a precarious social relation whose unity has to be actively constructed and maintained permanently. Furthermore, the state is characterised by strategic selectivity, insofar as "the state is not equally accessible to all social forces, cannot be controlled or resisted to the same extent by all strategies, and is not equally available for all purposes" (Jessop 1990: 317). The state can be seen as a battleground – a matrix – for struggles over political hegemony in terms of competing definitions of the common interest. Within this process of permanent reconstruction, technological policies, trade policies, and social policies are all mutually reinforcing discursive practices: "The articulation of (...) discoursive-strategic shifts into new accumulation strategies, state projects and hegemonic projects, and their capacity to mobilize support are shaping the restructuring and reorientation of the contemporary state and helping to produce new regulatory regimes" (Jessop 2002: 133). However, the attempt to organise actors, articulations, and meanings is usually only temporarily successful.

The guiding argument is, that the rise of nanotechnology is strongly connected to the development of certain tendencies that streamline state policies along allegedly competitive factors. The congealed form of these paradigms of competitiveness will be described as the discourse-organisation of a "competition state". A competition state can be identified as a discourse-organisation, insofar as it consists of a variety of different discourses that have been articulated in and through hegemonic practices. International competition has become important. Today, states are placed on the sliding scale of a global competitive indicator on the basis of their assumed competitiveness (ibid.: 119-120).

The discourse-organisation of the competition state frames a state aiming to secure economic growth within its borders, while ensuring competitive advantages for capital on its territory. This can be achieved by promoting the economic and extra-economic conditions that are perceived vital for success. It emphasises strategies to create, restructure or reinforce the competitive advantages of its territory, population, social institutions and economic agents. This discourse-organisation highlights certain characteristics that can be depicted as "Schumpeterian", "because of its concern with technological change, innovation and enterprise and its attempt to develop techniques of government and governance to these ends" (ibid.: 96). For Joseph Schumpeter, entrepreneurial innovation can proceed in different ways (cf. Lim 1990): via the introduction of a new good or a new quality of a good, via the introduction of a new method of production, via the opening of a new market, via the conquest of a new source of supply of raw materials or half-manufactured goods, and via the implementation of the new organisation of any industry. This approach highlights a prevailing thought of how society should be restructured in the light of a paradigm of innovation and competition. As it will be argued below, this narrative creates a link between nanotechnology and the industrial future of the advanced industrialised states. The notion of the competition state also has to be applied to competitive regions like the European Union.

4 Nanotech – a techno-socio-economical innovation strategy

The actual "nano-hype" plays an important role for the political contextualisation of nanotechnology in general, and for the present analysis in particular. "[F]or now the products seem relatively modest compared to the preceding hype" (Arnall 2003: 2). As the U.S. National Initiative (2003) states, "nanotechnology has the potential to profoundly change our economy, to improve our standard of living, and to bring about the next industrial revolution." It is suggested that nanotechnology is at approximately the same stage of development today as information technology was in the early 1960s, or biotechnology was at the beginning of the 1980s (c.f. Department of Trade and Industry 2002).

Both scientists and politicians promise revolutionary breakthroughs generated by nanotechnology: new ways of detection and treatment of diseases, in drug development, in the monitoring and protection of the environment (e.g. water decontamination), in the production and storage of energy, or in enhanced information and communication technologies. In their view, nanotechnology will enable to build complex structures as small as an electronic circuit or as large as an aeroplane, and produce stronger and lighter material (c.f. Royal Society/ Royal Academy of Engineering 2004: 1; Department of Trade and Industry 2002). Nanotechnology is perceived as an instrument to make powerful information technology available everywhere, to maximise productivity in agriculture, to increase health and longevity of human life, to provide abundant clean water globally, and to meet global energy needs with clean solutions.[4]

[4] See for example Foresight Nanotechnology Challenges (URL: http://www.foresight.org/challenges/index.html; last view 8 May 2008).

To understand the nanotechnology hype, one also has to take into account the most utopian expectations for future applications of nanotechnology. According to these visions, the most promising applications will stem from processes called "self-assembly" or "molecular manufacturing". Self-assembly refers to the tendency that some materials are spontaneously "able" to arrange themselves into ordered structures (c.f. Antón/ Silberglitt/ Schneider 2001). The goal and aspiration is to build desired structures from atomic scratch. The idea is not only to manufacture individual particles with useful properties, but to manufacture complex and useful structures made from multiple molecules. Hence, the desired outcome of nanotechnology is the manipulation and assembly of nanoscale particles into supramolecular constructions and even larger structures. Some scientists (most notably the controversial person of Eric Drexler) believe that one day molecular manufacturing will be possible, i.e. to control atomic positioning so precisely that any object whose atomic composition is known could be assembled from its basic units (Drexler 1986, 2001).

4.1 The nanotechnology market

In the following, it will be argued that the nanotechnology discourse is supported by different strategies, specified as the narrative of the nanotechnology market, the narrative of the knowledge-based economy, and the narrative of the nanotech-race. Economic interest in nanotechnology is not automatically given. Rather the interest itself is socially constructed and serves certain strategies. After years of basic research it is still uncertain if nanotechnology will produce substantial goods for the market. Nevertheless, there are countless studies that assess the possible impact of nanotechnology for future markets. Some sources state that by 2012 the entire market will be dependent on nanotech (c.f. Arnall 2003: 22). Although there are still only a few nanotechnology products on the mar-

ket, growth is expected to be strong, with a composite annual growth rate of 30–40% (c.f. Department of Trade and Industry 2002). The market confidence in nanotechnology is reflected by a number of forecasts. Miles and Jarvis (c.f. 2001) assess the market for nanotechnology-based IT and electronic devices at around US$70 billion by 2010. Roco and Bainbridge (c.f. 2001: 11) argue that nanotechnology will bear an annual production of about US$300 billion for the semiconductor industry, and about the same amount for global integrated circuits sales within 10–15 years. For micro- and nanotechnology systems in the telecommunications sector, the market is presently estimated around an amount of US$35 billion with an anticipated compound annual growth rate of around 70% (c.f. Arnall 2003: 22). The U.S. National Science Foundation (NSF) has predicted that the market for nanotechnology products will exceed US$1 trillion by 2015 (c.f. Royal Society/ Royal Academy of Engineering 2004: 1). In 2004, the NSF revised its forecast, estimating that the US$1 trillion market would come and go in 2011 (c.f. ETC 2005b: 6).

These immense expectations create an image of future markets, which is only achievable if the industry branches move up the technological ladder and align their R&D policies with the nanoscale. For this reason all advanced industrialised countries, almost all Fortune 500 companies and two-thirds of the companies in the Dow Jones Industrial Average, convey nanotech research, development, and investment in some way. The technological competence in nanotechnology is allegedly a compulsory condition to compete successfully with better procedures and products on future markets. At the same time, a view becomes hegemonic that does not permit any alternative to the development of nanotechnology, since the nations which fall behind will miss the junction to the future markets. Hence, nanotechnology becomes a synonym for innovation within the competition states. As nano-materials and -processes apply to many manufactured goods, in almost all industry sectors, control and ownership of nanotechnology is decisive for virtually all governments and for the competitiveness of industry: In terms of attracting initial investment, and to ensure future revenue. With certain patents it will be possible to control complete chains of production: "Don't bet the jockey. Don't bet the horse. Own the track" (Lux Research 2004: 186). Apparently, nanotechnology is the first research field in which the basic ideas and applications are patented from the outset: the most basic ideas and fundamental building blocks in nanotechnology "are either already patented or may well end up being patented" (ETC 2005b: 10). Hence, intellectual property rights are a key element in both, the knowledge-based economy and the global competitive struggle for (global) market shares, since "companies that hold pioneering patents could potentially put up tolls on entire industries" (Regalado 2004: 1). The "race" for the nanotechnology patent "gold rush" (ETC 2003: 24) has started among TNCs, leading academic labs, start-ups and universities.

4.2 The narrative of the knowledge-based economy

One feature of capitalist developments is the permanent process of primitive accumulation: the transformation of formerly "common good" into private property, the separation of producer and means of production, and the creation and enforcement of capitalist relations of production (c.f. Marx 2001: 741-791). The material (and often violent) process of primitive accumulation is mediated and backed up by an array of discourses. Within the competition state, the process of primitive accumulation refers more systematically and accentuated than before to knowledge and its commodification and privatisation (for the relation between primitive accumulation, genetic ressources and traditional knowledge see Wullweber 2004). Apparently, the factor "knowl-

edge" is getting more important for international competitiveness: "To create wealth and new employment in a globalised market and within a knowledge-based economy, the competitive production of new knowledge is essential" (European Commission 2004b: 9). Jessop (c.f. 2002: 96) describes the contemporary era, generally as a knowledge-based economy (KBE). The notion of the KBE can be conceived as a narrative within the discourse-organisation of the competition state supporting and articulating today's process of primitive accumulation. The KBE is the widely taken-for-granted focal point of accumulation strategies, state projects, and hegemonic visions. It is a nodal point, a privileged discursive point that partially fixes meaning within signifying chains (c.f. Laclau/ Mouffe 1985: 112).

The nanotechnology discourse concurs with the issue of knowledge generation and the narrative of the knowledge-based economy in policy speeches, documents, and programmes. Philippe Busquin, European Commissioner for Research, states that "nanotechnology provides a golden opportunity for the creation of new knowledge-based enterprises and has a 'revolutionary' potential that can open up new production routes" (European Commission 2004b: 1). Likewise, the EU Commission declares on its research homepage: "Nanosciences and nanotechnologies are crucial to the establishment of a knowledge-based EU society and economy" (European Commission 2004c). According to this logic, "Europe must (...) transform its world-class R&D in N&N [Nanosciences and Nanotechnologies] into useful wealth-generating products in line with the actions for growth and jobs" (Commission of the European Communities 2005: 2). Together these narratives frame nanotechnology as a competitive advantage for the industrialised countries.

4.3 International competition and the "nanotech-race"

Nanotechnology is framed discursively as a technology that is *the* pre-eminent factor for achieving a nation's innovation: It does not only introduce new goods but also offers a new quality of goods, it ushers new methods of production, it opens up new markets. And finally, it offers a new source of supply of raw materials. Nanotechnology is preordained as the magic tool leading to the production of ever smaller, faster and more efficient products with acceptable price-to-performance ratio. This has become an increasingly important success factor for many industrial branches in international competition.

Thus, the empty signifier nanotechnology serves as a techno-socio-economical innovation strategy. The U.S. National Science and Technology Council states (2003: 3): "Because nanotechnology is of such critical importance to U.S. competitiveness, both economically and technologically, even at this early stage of development, it is a top priority within the Administration's R&D agenda". In a similar way, the European Commission argues: "Advances across a wide range of sectors are being enabled through R&D and innovation in N&N [Nanotechnology&Nanoscience]. These advances can address the needs of citizens and contribute to the Union's competitiveness and sustainable development objectives and many of its policies including public health, employment and occupational safety and health, information society, energy, transport, security and space" (Commission of the European Communities 2005: 2).

The ascription to nanotechnology of being an innovation, and hence a competitive advantage, gives rise to an enormous global nanotechnology race among the industrialised nations. Apparently, the race is on to win monopoly control over the expected huge nanotechnology market and to win a share of the 2 mio. nanotechnology

workers, which are said to be required by the nanotechnology industry (c.f. Roco 2003). Between 1997 and 2006, government's investment in nanotech R&D increased from 432 million US$ to about 4681 million US$ a year (c.f. Roco 2007: 30). In 2007, industry and governments invested an estimated 13,9 billion US$ in nanotech R&D worldwide. In 2009, the U.S. funding for nanotechnology will grow to a sum of 1527 million (cf. National Nanotechnology Advisory Panel 2008: 9). The "nanotech-race" is now at centre stage of many government science and technology policies.

States play a crucial role in promoting innovative capacities, technical competence, and technology transfer. They hope that as many corporations and economic sectors as possible may benefit from the assumed new technological opportunities created by nanotechnology R&D activities. Within this competitive climate, the "systematic generation of science and technology (...) becomes an important area of the functions of the state administration" (Hirsch 1978: 94). The nanotechnology discourse, combined with the narratives of the nanotech-race and of a knowledge-based economy, supports the (re-)construction of the competition state. The competition state has to "focus upon (...) knowledge-based industrial innovation ('nanomanufacturing'), integration at the macro-micro-nano interface and interdisciplinary ('converging') R&D. Appropriate synergy with the European Strategy on Life Sciences and Biotechnology may also be beneficial" (European Commission 2004b: 8).

However, a nanotech-race is not simply existent. Rather, the creation of the narrative of a nanotech-race is the outcome of constitutive practices and hegemonic struggles. The actors within the nanotech-race are not acting independently from the different discourses, which in many ways have an influence on how these actors view the world, define their goals, and structure their actions. The perception of "a highly competitive global economy" (Her Majesty's Government 2005: 1), and the prevailing analysis that only those nations thrive "that can compete on high technology and intellectual strength" (ibid.), supports the narrative of the nanotech-race to become hegemonic.

5 Public acceptance – nanotechnology without antagonism?

As stated above, the success of a hegemonic project depends heavily on its public acceptance. Thus, the "public trust and acceptance of nanotechnology will be crucial for its long-term development" (European Commission 2004b: 19). Advocates of nanotechnology have to win the "perception wars" (Mitsch/ Mitchell 1999) to become hegemonic. In the field of GM-food, governments have already experienced that the governance of high technology is difficult. In the 1990s, GM-foods were value-detracted instead of value-added and the "perception wars are being lost by industry, one battle after another" (ibid.). Governments apparently try to pursue new strategies to avoid "another backlash like the one over genetically modified foods" (Boyd 2003) for nanotechnology. In my ongoing empirical research (cf. Wullweber forthcoming), I have identified several hegemonic stratagems[5]: a) articulation of the empty signifier; b) super-differential border-drawing; c) articulation of equivalence of different demands; d) legitimate difference; e) antagonistic division of the discourse; and f) expansion of the chain of equivalence. So far, the different strategies seem to be successful, since the resistance to nanotechnology is by no means as strong as e.g. the anti-GMO protests. In the following, the strata-

[5] The term "stratagem" denotes a generic term for different strategies that show "family resemblance" (Wittgenstein; cf. Nonhoff 2006: 207-240).

gem of "legitimate difference" will be shortly discussed.

Generally, the stratagem of "legitimate difference" aims to integrate potentially antagonistic positions into the hegemonic chain of equivalence. Potentially antagonistic demands become simple contradictions – legitimate differences – within the hegemonic project. These strategies strengthen the hegemonic project, because it can be indicated that critical actors are not only heard, but that they are part of the project in question. Their potential to mobilise critical societal forces is bound. Furthermore, a broader audience is addressed. The unit "Nano- and Converging Sciences and Technologies" of the EU-Commission declared: "It could be useful to involve powerful NGOs (for example Greenpeace) to attract a broader audience to dialogue" (Bonazzi 2007: 26). However, it is not about a one-sided integration: By involving certain positions and actors, the hegemonic project itself will be transformed to a certain degree.

The majority of people in the advanced industrialised states do not as yet have much knowledge about nanotechnology (for Europe cf. Eurobarometer 2006; Bundesinstitut für Risikobewertung 2007; for the USA cf. Priest 2006: 565; Kahan 2007). This poses a problem for protagonists of nanotechnology, because "[w]ithout a serious communication effort, nanotechnology innovations could face an unjust negative public reception" (European Commission 2004b: 19). With regard to genetic engineering "the lack of sufficient public scientific data on GMOs, whether positive or negative, was a controlling factor in the industry's fall from favour. The failure of the industry to produce and share information with public stakeholders left it ill-equipped to respond to GMO detractors" (Colvin 2003). Thus, advocates of nanotechnology start public debates, because "an open public dialogue with citizens and consumers is absolutely necessary as a basis for an objective judgement on nanotechnology and to avoid baseless fears" (Luther 2004: 94).

Many "nano-dialogues" are launched in countries, which run nanotechnology programmes. In 2005, a European Commission-funded project "Nanologue" was launched to address a Europe-wide dialogue on benefits, risks and social, ethical and legal implications of nanotechnology (cf. Nanologue 2005). In 2006, the European Communication Project "Nanodialogue - Enhancing dialogue on Nanotechnologies and Nanosciences in society at the European level" was inaugurated (cf. www.nanodialogue.org). A communication tool called "Decide – Deliberative Citizens Debate" has since been developed (cf. http://www.playdecide.org/). Furthermore, different citizen panels were organised: the so-called "NanoJury UK" in Great Britain (cf. Greenpeace 2005), a "consumer conference" in Germany (cf. Bundesinstitut für Risikobewertung 2006), the "Citizen Consensus Conference on Nanotechnology" in Wisconsin/USA (cf. Kleinman 2005) and others, for example in France, Denmark, the Netherlands and Finland. However, these dialogues are obviously restricted. They are "open" as long as they address "baseless" fears and construct an "objective", and, hence, positive judgement of nanotechnology. Critical recommendations are usually ignored, because they shall not slow down the process of technological development, but rather "reduce misunderstanding and obstruction" (Boyd 2003). Apparently, the overall goal of all these programmes is not to discuss possible problems but to achieve acceptance for nanotechnological development.[6] Not the risk of nanotechnol-

[6] In contrast, Schummer (2004b: 56) provides a more positive analysis of the current nano-dialogue: "That appears to be a great opportunity for cultural and social scientists to engage in partnership models with scientists and engineers such that both groups can immensely benefit from each other, for the overall benefit of the society."

ogy is at stake but its "smooth" development. Hans Kastenholz of the Swiss Federal Laboratories of Material Testing and Research, which is part of the Nanologue, states: "Consumer acceptance will be key for nanotechnology's future development and thus key for financial markets and venture capitalists. [...] Engaging society in a dialogue about the opportunities and potential risks will address and help to mitigate some of these uncertainties surrounding the issue" (Nanologue 2005). Nevertheless, this stratagem already produces lacks in the discursive structure: In January 2008, the Soil Association, the biggest organic certifier in Great Britain, declared to ban human-made nanomaterials from all organic cosmetics, foods and textiles that it certifies. For the past few years, the Soil Association has been part of a working-group on an industry labelling scheme, but it has been very unhappy with the reluctant government policies concerning risk regulations: "We are deeply concerned at the government's failure to follow scientific advice and regulate products. There should be an immediate freeze on the commercial release of nanomaterials until there is a sound body of scientific research into all the health impacts. As we saw with GM, the government is ignoring the initial indications of risk and giving the benefit of the doubt to commercial interest rather than the protection of human health" (Soil Association 2008). It may be a question of time, until resistance to nanotechnology will grow stronger – is this an antagonism à venir?

6 Conclusion

The aim of this paper was twofold: In a first step, tentative and explorative thoughts on an interdisciplinary *hegemony- and discourse-theoretical inspired political economy* approach have been delineated. In a second step, this theoretical matrix has been applied - still cautiously and exemplarily - to the policy field of nanotechnology. The theoretical approach provides a different perspective on the development of nanotechnology. While most of the current analyses treat nanotechnology as a definite technology, my thesis is that the term nanotechnology denotes an encompassing political project - a techno-socio-economical innovation strategy, that is kept together only by the empty signifier itself. Thus, a perspective is inaugurated that facilitates to delineate political interests and strategies within the process of nanotechnology development. Furthermore, it is possible to expound different discourses and policy narratives that have been associated with the nanotechnology discourse. While the discourse of international competition is fostered through the trope of the ongoing nanotechnology race, nanotechnology itself is presented as one of the most important strategies of innovation to win the battle for global market shares. To become hegemonic, a certain convergence of discursive elements is necessary. The success of the nanotechnology project derives from an alignment with the discourse-organisation of the competition state in general and the narratives of the knowledge-based economy, the nanotech-race and the immense future markets for nanotechnology. These discourses are mutually reinforcing and strengthening.

To a large extent, the development of nanotechnology is shaped by governmental technology policies (even though private actors become more and more important). Today, these policies are predominantly characterised by an accelerating commercialisation. From this perspective, nanotechnology is *the* pre-eminent factor for achieving innovation and competitive advantages: It introduces new goods and offers a new quality of goods, it ushers new methods of production, it opens new markets, and, it offers a new source of supply of raw materials. However, the enforcement of new technologies is no automatic, self-evident process. It rather is embedded in social relations and has to be backed by political measures. Nanotechnology

has to be embedded in modified governance structures, which currently materialise in the political form of the competition state. For this new mode of socio-economic regulation the "consent of the ruled" is required. Regarding nanotechnology, different strategies are performed to win the concurrent "perception wars". Nanotechnology advocates in governments must pursue policies supporting a positive climate for business *and* a favourable public perception. Therefore, they try to invoke different discursive elements in order to strengthen the perception that nanotechnology is indispensable for an economically viable society. While the future for the nanotechnology project is still uncertain, the policy field remains challenging.

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