Modeling for Policy

Science-based models as performative boundary objects for Dutch policy making

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This paper investigates the role of models for policy by drawing on and exploring the tensions between the notions of boundary objects and performativity. The notion of boundary object has proven to be useful in gaining a better understanding both of the hybrid character of science-based models and their role in the coordination between different social worlds. However, by assuming that these worlds remain stable, an investigation into the performative nature of models tends to be overlooked. Therefore, this paper investigates how models are constituted by negotiations between scientists and policymakers and at the same time constitute social worlds. It examines two simulation models developed in different Dutch policy contexts: a macroeconomic model for the health care system and an ecological landscape planning and assessment model. The paper shows that models not only actively coordinate social worlds but also contribute to changing them. The performativity of models ranges from generic (instrumental) to substantial as they influence social worlds to the extent that these worlds start behaving the way models describe.

Keywords: models, boundary object, performativity

Scientific knowledge in policy making processes is often applied in the form of simulation models. Such models have since long been used by governments to predict e.g. (financial) consequences of policy measures. The past decades have shown an increasing use of such models as important tools to support policy making and policy decisions in many national and international policy fields (e.g. Edwards, 1999; Hordijk, 1991; Morgan & Den Butter, 2000; Sundberg, 2007; van den Bogaard, 1998; van Egmond & Bal, forthcoming). The growing importance of simulation models in policy making processes leads to the question of how scientific knowledge, policy questions and demands are brought together in such models and the consequences thereof for the social worlds of both policy and scientific research.

Philosophical discussions around models have centred on epistemic issues, with little attention to relations between modeling practices and policy practices. Other studies on models show how

models for policy making are the result of scientific, professional and policy interaction (e.g. van Daalen, et al., 2002; Evans, 2000; Mattila, 2005; Shackley & Wynne, 1995). The notion of boundary object, first discussed by Star & Griesemer in 1989, has proven useful to draw attention to the hybrid nature of scientific tools such as models. Boundary objects coordinate between social worlds, e.g. on the interface between science and policy (Bal, 1998; Halffman, 2003), and therefore allow these social worlds to remain stable. This paper contributes to this body of literature by drawing on the notions of boundary object *and* performativity.

We suggest that boundary objects often 'do' more than bring together and coordinate social worlds. Boundary objects play a role in establishing facts as parts of standardized packages (Fujimura, 1992). Therefore, they are active constituents of social worlds and may change those they function in (Callon, 1998; MacKenzie & Millo, 2003). In assuming that the value of the concept of boundary object lies in the idea that different social worlds can communicate, interact, collaborate and, at the same time, remain dissimilar and relatively stable, analyses of boundary objects often conclude at the moment the boundary object has been established. What a boundary object 'does' is then taken for granted (Zeiss & Groenewegen, 2009). The ways in which boundary objects do change the social worlds they coordinate has thus been under-explored. It is however crucial to understand their performative nature to investigate and comprehend the increasingly important role of models in policy making.

This paper contributes to a better understanding of the performative nature of boundary objects. In showing the boundary object character of two models as well as their performative nature, we also address the tension between these notions: how are boundary objects performative? In other words, how can they coordinate and demarcate relatively stable different social worlds while at the same time shaping these worlds? As most literature focuses on 'single model' studies, this paper provides a unique comparison of two detailed empirical accounts of two simulation models. These were developed in different (Dutch) policy contexts–a macro economic model for the health care system and an ecological model for landscape planning and assessment–by different science advisory bodies. Both models are used for policy planning and assessment by the Dutch government.

We start with a discussion of the literature on models. After introducing the two policy fields and models, we investigate how negotiations between scientists and policymakers constitute models and show how models themselves can constitute the reality in which they are at work. In addressing the tensions between the notions of boundary object and performativity, we argue that science-based models for policy as boundary objects are not only performative in the coordination of socials worlds on what we call a simple or generic level, but can also be performative on a more substantial level, as they do affect actual practices and the behaviour of social worlds.

Scientific Models as Boundary objects

Models, in the broadest sense of the word, are formal or informal simplified representations, descriptions or imitations of (potential future) 'realities'. Increasingly, scientific models are run on computers. Two such computer models are explored in this paper.

These models, as we will explain later, are both simulation models. They are used to explain complex and dynamic systems; these models can be dynamic or static. We call them science-based or scientific models because they are products of scientific research and are subject to common scientific practices such as quality assessment and peer review (Yearley, 1999). Yet, although these models are science-based, they also contain policy elements.

Many studies have concentrated on explaining the role of (the construction of) models in the utilization of scientific knowledge. Much attention has been given to the use of models in the production of scientific knowledge (e.g. Mattila, 2005; Morgan & Morrison, 1999; Knuuttila & Voutilainen, 2003). Philosophical discussions on models have centred around epistemic issues, with little focus on the relationship between modeling practices and policy practices.[1] This relationship has been explored in more detail by social science and policy scholars who have concentrated on the role and importance of models for political decision making processes and policy development (e.g. Bal, 1998; Edwards, 1999; Halffman, 2003; Jasanoff, 1995; Shackley & Wynne, 1995), evidence-based policy making, and the accountability of policy programs (e.g. Evans, 2000; Jasanoff, 1990; Yearley, 2003; Yearley, 1999). Simulation models, as Merz (1999) argues, can be epistemic objects and technological things at the same time and have, thus, different meanings to different users. Moreover, models provide 'discursive spaces' in which uncertainties are negotiated and shared understandings are created[2] between developers and policymakers (Evans, 2000). These studies show the role of science and policy interactions in relation to the constitution of policy facts, and they show that the distinction between 'science' and 'policy' is often difficult to make.

The notion of a boundary object has proven useful to draw attention to this hybrid character of science-based policy tools such as models (e.g. Agrawala et al, 2001; Halffman, 2003). Boundary objects (Star & Griesemer, 1989:393) are used to manage the "central tension" that exists in the interaction between social worlds. They "inhabit several social worlds, (..) *and* satisfy the informational requirements of each of them" (Star & Griesemer, 1989: 393). Because such objects are flexible, they can have different meanings to different social worlds: their structure remains "plastic enough to more than one world to make them recognizable" (Star & Griesemer, 1989: 393) to each world. They are "simultaneously concrete and abstract, specific and general, conventionalized and customized" (Star & Griesemer, 1989: 408). This enables different social worlds to connect, while remaining concurrently accountable to both worlds. In other words, the boundary object has the ability to adjust to the needs of both worlds, while the social worlds remain intact.

The value of the notion of a boundary object lies in the idea that different social worlds can communicate and at the same time remain dissimilar and relatively stable. Most science and technology studies (STS) literature on boundary objects has concentrated on the process with which an object becomes a boundary object: [a] "boundary object is regarded as the *result* of something becoming successful (the explanandum) rather than the *cause* of its success (the explanans)" (Zeiss & Groenewegen, 2009: 93). Once it is established, the coordinating nature is taken for granted and not

further explained. Models as boundary objects, however, do more than provide negotiation spaces for the social worlds involved; they can coordinate worlds in different ways and they carry in them facts that are the result of negotiations. As such, modeling practices and using models are ways of creating facts.

This feature of boundary objects has been described beautifully by Fujimura (1992) who combines notions from social worlds theory and actor network theory. Fujimura discusses boundary objects as part of a standardized package, which is described to include ambiguous concepts and standardized tools of methods and theory, such as data collecting and processing tools, computers, etc, that "help to explain how [a] theory can be continuous across time and space through different social worlds" (1992: 204). A standardized package differs from a boundary object in that it is used "to define a conceptual and technical work space which is less abstract, less ill-structured, less ambiguous, and less amorphous" (Fujimura, 1992: 169). However, we argue that the difference between boundary objects and standardized packages is not as clear-cut with regard to models. Simulation models can, on a smaller scale, be regarded as standardized packages themselves, as they contain some of these elements of standardized packages (e.g. theory, standardized methods, computer tools). Conversely, standardized packages can themselves be regarded as boundary objects, for instance, in situations where separate social worlds have to cooperate or come to workable models and yet have to remain accountable to their own social world. This is the case for scientific models used for policy making that need to be accountable to both scientific standards and policy usefulness.

We show that boundary objects, like standardized packages, can become embedded in particular practices and become stable in the sense that they have been used as policy tools over a long time. Boundary objects are not necessarily more easily reconstructed and are, thus, not "disadvantageous" for providing stabilization (Fujimura, 1992: 169). More importantly, as facts are constructed in the process of modeling, models are active constituents of the society or culture they are embedded or developed in. Models carry in them 'ideal' representations of the world positioned by the experts that develop the model (see also Knuuttila, 2005; Weisberg, 2007). In that sense, we argue that models as boundary objects create a new world. As such, they can be performative beyond coordinating social worlds; they can change the social worlds they function in since these worlds have to relate to the ideal world presented in a model.

This article describes two case studies in which reconstructions were made of two models which were developed in different (Dutch) policy contexts– health care economics and ecology– and by different science advisory bodies. Our case studies are based on sixty semi-structured interviews[3] that were held with persons involved in the development of the models, including members of the project groups from the respective science advisory bodies, concerned departments of the Ministries, and involved data providers. Some of the actors were interviewed more than once. Furthermore, document analysis was done based on archives of the Netherlands Bureau for Economic Policy Analysis, the Ministry of Health, Alterra, and the Ministry of Agriculture, Nature, and Food Quality (LNV). This analysis contained official letters, proposals,

minutes of meetings, notes, progress reports, and evaluations of the projects. The data collection took place between February 2004 and September 2007.[4]

Two policy fields - Two models

Both the care model and the ecological model are used for policy planning and assessment by the Dutch government. They are developed by science advisory bodies which represent a particular instance of the use of scientific knowledge in governmental policy making that is typical for the Netherlands. The different science advisory bodies have a central and formalized position in science based policy assessment for the government, albeit on different policy domains. They make use of scientific knowledge and insights (e.g. economic, sociological, epidemiological, and ecological insights), including the use of models, in their analysis and publications. As typical examples of places where such interaction takes place, these institutes form a perfect place to study the interaction between science and policy. These institutes involve actors from several social worlds, for instance during the construction of simulation models that are often used for the assessment of policy proposals, and exist at the boundary of both policy and science, though having distinct lines of accountability to each (Guston, 2001: 401).

The care model was developed by the Netherlands Bureau for Economic Policy Analysis (further: CPB), which is regarded as being an expert in economic modeling and policy assessment (e.g. Den Butter, 2003; van den Bogaard, 1999), in cooperation with the Social and Cultural Planning Office (SCP), which is regarded as being an expert in micro economic modeling with a focus on socio-economic issues in Dutch society, such as effects of health policy measures on e.g. the accessibility of health care for individuals (Trommel, 2003). The third party was the National Institute for Public Health and the Environment (RIVM) that deals with many public health issues (van Egmond et al, 2007). These three science advisory institutions[5] are authoritative in the use of simulation models for the assessment of policy proposals for the Dutch National Government.

The need for a care sector model derived from political and economic circumstances in the 1980s that caused Dutch politicians to be faced with structurally rising costs in the health care sector. The economic models used by the Ministry of Health proved both insufficient in explaining why and how health care expenditures increased so quickly and what could be done about this (VWS, 2004, interview 040512). Moreover, the Ministry of Health lacked knowledge about epidemiological trends (Boer, 1987). Politically, the government shifted towards a new public management of governmental policy making; more accountability and transparency of public policy and its effects, which was a trend visible in other European countries as well (e.g. Hunter, 1997; Walsh, 1995; Ashmore, et al., 1989). The succeeding Cabinets proposed market based policy programs to fundamentally change the (financial) organization of the sector (Helderman et al, 2005). These were, however, badly received, both politically and within the sector, sparking many heated political debates. Under these circumstances, an interdisciplinary project was commissioned by the Minister of Health. The choice to ask these three science advisory bodies to work together on one project was not self-evident. However, the involvement of these three

authoritative institutes each working on health care issues was required to provide the Minister with unambiguous policy answers for many parties.

The LARCH model–LAndscape ecological Rules for the Configuration of Habitat–is used to assess the viability of animal populations in fragmented landscapes and thus the potential of biodiversity (van der Sluis, et al., 2003). It simulates whether a certain landscape is able to support a sustainable animal population. The model will show where a landscape is too fragmented and what the effect will be of, for instance, an ecoduct on the viability of a population (Alterra, 2007). It was developed in the early 1990s at the department of Landscape Ecology at the State Institute for Nature Management (RIN). RIN later became part of the Directorate Agricultural Research (DLO) of LNV and, in 2000, part of the research institute Alterra.

The Netherlands is one of the smallest and most densely populated countries in the world, and due to increasing urbanization and industrialization the landscape has progressively been fragmented. Nature protection in the Netherlands from the 1960s until the 1980s mainly consisted of the maintenance of existing nature areas and the purchasing of new areas. This shifted in the 1980s when ecologists, working at the Ministry of Agriculture, Nature, and Food Quality (further: LNV), framed landscape fragmentation as a public policy problem inspired by theories of island biogeography and metapopulations (Turnhout, 2009; MNP, interview 051029). The idea is that if landscapes become more fragmented, the number of populations and the possibilities for migration decrease. Since smaller populations become extinct more easily than large populations, nature policy had to focus on creating large nature reserves that are joined together or otherwise linked by corridors or stepping stones.

In the 1990 Nature Policy Plan, the notion of 'national ecological network' (NEN) became the basis for nature policy in the Netherlands. Alterra researchers had been engaged with questions concerning landscape fragmentation and the metapopulation theory from an early stage. When field studies showed that animal populations in the Netherlands were affected by nature fragmentation and that this was a generic problem, the idea to build a model that assesses whether a population is viable in a certain landscape, was born (Alterra, 2005, interview 050217).

Connecting social worlds through models - Care and LARCH as boundary objects

Creating a Priori Standards for Modeling

Models can be regarded as boundary objects that bring together several social worlds. They are 'discursive' spaces where social worlds can meet. This enables negotiations between scientists and policymakers about the parameters of the model (Evans, 2003) and to put scientific as well as non-scientific elements together to create a model to support policy making. It is in fact this feature that enables models to mediate effectively between 'theory' and the 'world' (Sismondo, 1999). There are no general rules for the construction of models, but it involves "elements of theories and empirical evidence" (Morgan & Morrison, 1999: 15). As is argued by Boumans, these ingredients are integrated in such a way that the model meets a priori set standards (Boumans, 1999).

Interestingly, these a priori set standards however, differed in both models. At the start of the care model construction,

the project team formulated three goals with regard to the models' content. This was done with the help of a fourth party in this interdisciplinary project, the Macro Economic Labour Section (MEEVA) of the Ministry of Health. This section had taken up the task to host the project and provided a project secretary who was responsible for the financial organisation of the project.[6] The specific formulations of the aims of the project connected the scientific worlds of the science advisory bodies with the policy world of the Ministry. It connected the social aspects of government policy and health through the SCP, RIVM's expertise on health trends, and CPB's expertise on macroeconomic modeling with the macroeconomic policymakers.

The model firstly needed to explain past developments in the use and costs of health care on the macroeconomic level. Second, it needed to calculate the future effects of possible financial-economic policy options on the macroeconomic level. Finally, it needed to show the effects of possible health care and prevention policies on the demand and supply of health care and its consequences for health care costs (Pre-study, 1994). The first two questions required the economic modeling of the structure of the health care system, whereas the third question required the modeling of public health issues and epidemiological trends. The project team was also faced with the difficult task of integrating these three approaches to modeling health care. Because there had previously been no such attempt, the care project became a unique attempt to bring together micro-economic knowledge (e.g microsimulation modeling), knowledge about public health trends (epidemiological approaches), and macro-economic knowledge for the first time at this scale.

LARCH was developed by a team of ecologists, and had no explicit policy question at the basis of the model, as did the care model. However, the theoretical basis for the LARCH model was much stronger. The issue of landscape fragmentation had become a prominent issue both in the ecological theories taken up by Alterra researchers and in the 1990 Nature Policy Plan based on these theories. The LARCH model was built on two developed theories: the island theory and the concept of 'metapopulation'. The island theory was developed by MacArthur and Wilson - *The theory of island biogeography*. This theory states that the number of species on an island depends on a balance between the rate of extinction on the island and the rate of species immigration or colonisation of the island (Begon & Harper, 1996). This balance is influenced by, for instance, the size of the island and the distance to the mainland; islands closer to the mainland with larger habitat areas tend to have greater species diversity than islands further from the mainland. This theory cannot, however, comment on the question of which species could be expected in a certain area.

The concept of metapopulation (Levins, 1969)–a group of spatially separated (sub) populations of the same species which interact through migration–helps to address this problem. An individual population lives in relative independence of other populations and can go extinct, but a population as a whole is often stable because immigrants from one population can re-colonize the habitat of the extinct population. The connectivity between seemingly isolated populations that guarantees the survival of the species as a whole is thus central to the idea of 'metapopulation'. The ecologists working at LNV in the early 1980s advocated an ecological network

consisting of nature reserves in which no agricultural activity would take place and presented this in a policy document on nature development (Baerselman, 1988; Turnhout, 2003).

On the basis of these theories and the policy document, an adjusted ecological network was designed, including 'cultivated' landscapes in order to mobilize (bureau) political and public support for the idea (Visser, 2006). LNV ecologists provided policy advice on how to build the national ecological network (NEN). LARCH was built in this context to assess the viability of animal populations in fragmented landscapes and thus the potential of biodiversity. Policy questions developed as researchers and policymakers continued working on the construction of the NEN but were strongly supported by available theoretical concepts on animal populations.

Science-based models that are developed by advisory institutes, such as the LARCH and the care model are neither fully scientific nor fully policy-oriented. However, our cases show that some models can be less science based at the outset than others. In the care model project, clear aims were formulated for the model based on policy wishes rather than based on available theory. LARCH, however, could be developed on the basis of the available theoretical concepts and empirical field research. It developed in parallel with the articulation of nature ecology networks as public policy problems but was hardly steered from the policy side. The Dutch health care sector at this stage lacked such a supportive theory.

Model Construction: Negotiating Health Economics – Negotiating Ecology

Models that are often employed by experts for policy assessments have to be scientifically sound yet useful for policymakers. However, being useful entails that a model meets a broad set of criteria. Models carry in them bits of theory and bits of the 'world' (data) as representations of the reality that it needs to represent (be that theory, the world or something in between) and other elements such as tacit knowledge and experience of the model-builder (Evans, 2000; Morgan et al, 1999). The actual process of model building is, as Bouman has argued, like a "trial and error process till all the ingredients, including the empirical facts, are integrated" (Boumans, 1999: 95). Modeling is thus a constant shifting from data to theories and back, which occurs several times until something 'useful' has come up and is negotiated by the experts involved.

The care project team struggled with the need to be simultaneously scientifically sound and policy-oriented because of the combination of three different epistemological, theoretical approaches. This was made more difficult by the need to use as much empirical data as possible. A project member explained that "to simultaneously connect micro level derived demand and supply with demand and supply at an aggregated macro level is extraordinarily complex and will in practice lead to immense practical problems" (SCP, 2004, interview 040422). Outcomes on the macroeconomic level are as of yet very hard to derive from micro data analysis.[7] The solution that was sought was to limit the focus of the model to explaining past developments in costs of health care and to first make an *"accurate"* description of the policy field (Pre-study, 1994). This solution was endorsed by both State Secretary Simons and the project secretary from the Ministry of Health. This, nevertheless, reduced the role of

the RIVM and the public health approach and, consequently, limited the scope of the model to an economic one.

Moreover, at this stage of the project, political discussions and scientific discussions began to intertwine more openly. Now that the RIVM's role was reduced, the role of macroeconomic policymakers from MEEVA became more important, influencing the kind of 'reality' that was represented in the model. This became most visible when demand was modelled. At first, three options were available to model the parameter demand. The first option of the team was to not take into account the demand side of health care by treating demand as an exogenous factor. This choice, however, was not in line with political discussions on how demand can be influenced. The authors argue that:

> The not taking into account of demand effects would imply that we lay on the model the fact that own payments for GP consults or specialist consults do not have any effect on the production of health care. Given the prominent place of the issue of own payments in the [political] discussion on cost containment in health care, it seems irresponsible to not build such an assumption into the model (In: CPB and SCP, 1995:6).

Here we see that the political context of the model–the content of political discussions–directly influenced the shape of the model.

The second option, favoured by SCP, was to develop a dynamic model based on actual descriptions of the behaviour of the actors in the field. Such a model would be in line with the aim to incorporate microeconomic notions with macroeconomic modeling practices. However, a dynamic model requires lots of data and would make the model very large and prone to uncertainties and fluctuations, especially as the available data–as is true in this case–was of a poor quality. The third option, favoured by CPB, and eventually put in the model, was to develop a structural model that provided a description of the structure of the policy field based mostly on the available theoretical notions of economics and health economics.

LARCH was developed by a very stable research team–the people who were involved in the construction of LARCH are still part of the team fifteen years later–and with only one main disciplinary background involved (ecology). Due to the similar academic backgrounds of the researchers involved, problems with combining different theoretical approaches rarely occurred.[8] Problems encountered focused not so much on theoretical problems but on 'contextual' elements such as modeling skills, computer capacity, how to model dispersion of species, and what arithmetic methods should be used. For example, according to one individual, "we used to wish that we could calculate the distances between all nature areas, but in the beginning we couldn't do the calculations for the distances between one thousand or 10.000 swamp areas; now we have a Table of these areas and we don't have any problems with calculating distances" (Alterra, 2004, interview 041020).

Although the model was initiated and developed by researchers, they wanted the model to be useful for policy and sometimes tried to involve policymakers in the decision making about parameters needed for the model. One such example is the definition of a 'viable population'. The output of the model consists of data about the viability of populations and therewith the extinction probability. However, to assess network cohesion

and viability, an index is needed which involves both ecological and political decisions: "It entails decisions regarding whether one sustainable network is enough, whether 50% should be sustainable, or even all networks" (Opdam et al. 2003:120). It also includes political decisions regarding the set of target species included in the assessment (i.e. which species are seen as more valuable) and about e.g. what percentage of area with at least what percentage of the species should be sustainable. These decisions inform the outcome of the model in terms of what can be defined as viable populations. Researchers maintained that these decisions should be made by policymakers. Namely, "the question of what risk level should be used is not one for ecologists to answer but rather one for managers" (Verboom, 2001), and instead "the policy-maker should decide whether the consequences of such decisions are acceptable" (Alterra, interview 050217). Yet, the researchers received little input from policymakers; consequently, they themselves chose a definition of population viability with a risk level of 5% per 100 years. Out of every 20 species, they were willing to risk losing one every 100 years.

The model was first applied in 1995 in the project "Ecological networks in river rehabilitation scenarios: a case study for the Lower Rhine" (Reijnen, 1995). However, the model remained continuously in development. Despite little involvement of policymakers in the definition of parameters and assumptions for the model, the changing context in which the researchers worked and particular policy questions increasingly influenced the shape and content of the model. The period following the first application of the model in 1995 was characterized by the externalization of the in-house expertise from the Ministry of LNV and increasing project-based and output-centred research. The research team that developed LARCH had been part of LNV and had worked as civil servants until the year 2000 when the DLO (Directorate Agricultural Research) institutes were legally privatised and Alterra was founded. Formally, Alterra and the researchers were now independent from policy, but research projects could now only be carried out when research was commissioned–often by LNV. As a result, LNV could commission any institute to carry out the research that they deemed important for policy making. As a consequence, it is claimed that:

> Researchers at institutes of Wageningen UR work differently than they did in the 80s: project-based, output-centred. (…) The new procedures result from the changes around the management and financing of the institutes: at a distance, demand driven output funding rather than input driven funding, in the form of a Public Limited Company [plc] rather than as a government institute. (Grin, 2004.)

This is confirmed by the Alterra researchers, one of whom states that the "freedom" the researchers used to have changed when Alterra became a market based institute that needed to acquire funding for research:

> When I started working here [IBN-DLO], 16, 17 years ago everyone worked on what he/she thought was interesting. Today we need to account for all our time and can only work on something when a paying commissioner is involved. We do

> what for instance the Netherlands Environmental Assessment Agency finds important and is willing to pay for. This is due to the privatisation of Alterra and the decrease of government subsidy. (Alterra, 2004, interview 040928).

Researchers could no longer build the model according to what they thought desirable. Instead, they had to take a more pragmatic approach: what is feasible within the time and money constraints that we have and what policy purpose should the model serve?

As in the case of the care model, this raised the issues of balancing scientific and policy needs, of what needed to be represented and of the translation of politically sensitive issues. Uncertainty in the form of lack of available data, for example, represented a problem for researchers in some cases with regard to the scientific status of (the outcomes of) the model. For policymakers, however, this uncertainty could be irrelevant: "small uncertainties in a model are not likely to influence for example the decision to extend the NEN with robust corridors; uncertainties in policy making and with regard to other uses of land and nature, such as recreation, are of a different scale than the uncertainties in science and in the model" (Alterra, 2004, interview 041027). Since the research was often project-based, questions about how to deal with uncertainty were negotiated on a case-by-case basis. The issue of representation is illustrated by the choice for specific indicator species. In order to work with the model in the context of the NEN, indicator species had to be chosen which would represent other species in the distances it travels, the habitat it lives in, etc. LARCH would then assess the viability of these indicator species in various nature reserves. Much knowledge needed to be available about these species, but to create political legitimacy, they also needed to be furry and cuddly (MNP, 2005, interview 051029).

These seemingly scientific discussions concerning the respective data-versus-theory-ladenness of models that was present in both modeling processes tend to mask their political dimension. Edwards argues that the model/data relationship should be viewed as "symbiotic, rather than oppositional" (Edwards, 1999:454). The reason for this is that "the purpose of simulation models is not to explain or theorize, but to forecast by creating analogues based in both theory and data" (Edwards, 1999:454). Edwards shows empirically that data and theory are constituted by each other: facts (or data) are theory-laden, and theory is data-laden. The question of whether the data or theory is sufficient enough for the occasion is, thus, not a technical discussion but an epistemological discussion. Facts provide scientific credibility for theories. Theory-laden models, however, provide experts with control over the presence of certain facts in a model: which facts you put in a model, and which ones you leave out. The care model team chose to rely on theory by building a structural model and to test it with data as it became available in later years. Herewith, the team favoured political legitimacy of the model over theoretical legitimacy. In the model construction of LARCH, the political and scientific legitimacy seem to have been treated more equally. Political legitimacy was a desired objective at the start of the model and became a requirement (also for maintaining and further developing the model) due to Alterra becoming a market-based institute. The selection of furry and cuddly animals as indicator

species (MNP, 2005, interview 051029), illustrates this. Scientific legitimacy was also important at the outset and remains so, also to achieve political legitimacy

The Care and LARCH Models as Boundary Objects

Models that are used for the assessment of policy proposals act as boundary objects between policy questions and scientific practices; they simultaneously keep together and keep apart social worlds. Moreover, as we have seen, seemingly scientific discussions are often disguised political discussions situated at the "interface between science and policymaking" (Edwards, 1999: 462). This is, as our cases show, especially so for science-based models for policy making, as these have to account for scientific and policy worlds concurrently. Interestingly enough, in our case, economic experts seem to lean more towards the needs of policymakers and less to the scientific world, whereas the ecologists seem to account for both worlds more equally. The models described here are in that sense boundary objects with different consequences.

The care model is a boundary object for different scientific disciplines in that it provides a negotiation space to 'depoliticise' political problems (Jasanoff, 1995). However, its ability to serve as a boundary object between scientific disciplines proved limited; instead, it acted as a division tool for the scientific parties involved. It contributed to endorsing existing differences between the SCP, CPB and RIVM, the Ministry of Health and related institutes concerning how to cope with health care issues such as efficiency, scarcity, and solidarity. It did, however, bring together macroeconomic modellers and specific health policymakers. The idea behind the care model was to use it for the assessment of policy measures developed by the Ministry of Health regarding the regulation of costs of health care and to gain a sense of to what extent different parts of the health care sector would be financially affected by certain financial policy measures. The initial use of the 1999 version of the model was, however, limited. Involved policymakers questioned its usefulness for policy assessment, as it was said to be "only a distribution model" (Ministry of Health, 2004, interview 040512A). Accounts from previous years were put in the model to see where changes would occur, as opposed to using it as a simulation model to predict future developments.

LARCH, like the care model, incorporates politically normative standpoints and contains elements of both science and policy. LARCH provided not necessarily a space to depoliticize problems but certainly a space to tinker with policy questions related to the NEN. In addition, some of the boundary nature of LARCH is found in its 'stable variations'. Since LARCH has often been used for ad hoc projects and different applications, a number of building blocks (modules) of the model have been developed, which we call 'stable variations'. LARCH-SCAN is, for example, based on the dispersal capacity of species and delivers species' specific results, whereas LARCH-EUROPE assesses the biodiversity potential in fragmented European ecosystems. The stable variations of the model provide the model its boundary object features, allowing it to be flexible enough to be used to investigate certain policy questions, yet stable enough to prevent the high costs and time involved in adjusting the model.

Models as Performative Boundary Objects

In discussing simulation models that have come to play an important role in policy making, we argue that mainly pointing to the coordinative role of models as boundary objects is not sufficient to understand the much more performative character of models. Models provide negotiation spaces for the social worlds–e.g. social worlds of scientists and policy-makers involved in modeling practices–and serve as tools to coordinate these worlds. They carry in them facts that are the result of negotiations that took place during the model construction. As such, models have embedded in them (new) facts that influence social worlds and help to create (new) realities that have been the result of negotiations that took place during the model construction. Thus, models are active constituents of the context they are constructed for, be it the scientific world, the policy world, or another world. Callon and others have referred to this as performativity (Callon, 1998; Callon & Muniesa, 2005; MacKenzie & Millo, 2003; Garcia, 2007[9]). The notion of performativity may, thus, aid us in understanding how models–in this case they can also be regarded as boundary objects–also actively change practices and social worlds.

However, the concepts of boundary objects and performativity also create an interesting tension. The notion of boundary object, which originates from social worlds theory, refers to ways in which different social worlds can interact and relate without having to change, for instance, through the flexibility and coordinative role of objects (such as models). The notion of performativity derives from the context of actor network theory and focuses on the role of materiality in the shaping and forming of facts (Latour, 1999). Thus, while boundary objects are about how dissimilar, already existing social worlds can relate without having to change, performativity is about how such objects shape and form the world in which they are to operate.

Although these concepts seem mutually exclusive with regard to the stability of social worlds, both the idea of a boundary object as introduced by Star and Griesemer (1989) and the idea of a standardized package as introduced by Fujimura (1992) can be seen as attempts to integrate both theories with the help of (a) material device(s). In engaging with MacKenzie's levels of performativity, we aim to do justice to the boundary object nature of science-based models for policy as well as to their performative character that goes beyond their function as a boundary object. Scientific models for policy making, on the one hand, bring together social worlds and enable these worlds to work together and to negotiate knowledge and policy. However, as we show, these models are at the same time also material actors. They bring with them a new social world made out of elements of the social worlds involved in constructing these models. As such, they are tools through which facts–reality–are made; they are performative.

MacKenzie's classification of performativity has been helpful in unravelling performativity as a theoretical concept. Performativity is explained in several steps. Generic performativity happens when an aspect of economics or another discipline, be that a "theory, model, concept, procedure, data-set, etc." (MacKenzie, 2007: 55), is used in daily life. He uses the term effective performativity when the use makes a difference to this reality. These two forms of performativity are, however, superficial

enough to keep the social worlds involved in place. The care model project, for instance, brought together different disciplines that had not worked together previously on health care. The project did not succeed as a collaboration project at the time, and the parties involved fell apart, while the project continued as a one-disciplined project occasionally consulting other experts. Effective performativity was evident for the reason that the different parties were involved and became acquainted with each other's epistemologies.

However, the model as a boundary object effectuated more than this alone. It also provided the CPB with a new knowledge tool for a policy area it previously had refrained from. As such, the model has extended the CPB's authority in the Dutch policy arena and created a new authoritative institute in health care alongside others (such as the SCP and RIVM). In this respect, the model also works as a disciplining tool for other actors in the field in a few ways; the model has forced data providers to register data that formerly was not registered. Other actors in the field of health care now have to relate to the macroeconomic perspective provided by the CPB. In that sense, the model also actively shaped social worlds in health care. MacKenzie describes this as Barnesian performativity. This takes place when the use of theory or models makes reality–in any form–behave more like the depiction of that reality in theory, such as a model.[10]

The care model has in that sense also contributed to a shift in the science-policy boundary in health care towards a more economic approach to health care. Although the government had used a cost containment strategy of supply regulation since the 1980s, the model incorporated a market oriented approach that was visible in the demand parameter. This limited the use of the model for policy assessments based on the supply regulation system. Although the notion of a market oriented health care system was not seriously being considered in the debates concerning a new policy program until the beginning of 2000[11], the model incorporated a market based notion long before the government. As the model incorporates a market oriented policy program, it helped to articulate, make stronger and put on the agenda a market based policy program (van Egmond & Bal, forthcoming). Once a policy approach has permeated many governmental institutions, it becomes more difficult to argue against such a policy approach. As such, the model has served to legitimate new governmental policy directions regarding the health care system.

The use of LARCH can also be analyzed through the notions of generic and effective performativity. The externalization of the 'in-house' expertise of LNV into Alterra provided LARCH with an opportunity and necessity to more consciously bridge and coordinate the scientific and policy world which strengthened its function as a boundary object. LARCH has been used for ad hoc projects, often in relation to quick policy recommendations and quick scans for LNV and other Ministries (Verboom, 2006). It has, for example, been used in a project by the LNV to assess the ecological effectiveness of 'corridors' between nature reserves; on the basis of LARCH, it was decided whether each corridor should be funded or not. The ecological corridors that had originally been drawn by LNV had been heavily criticized for the lack of scientific input to assess their ecological efficacy. These corridors, with the exception of those with legal commitments, administrative

commitments, robust corridors which were ecologically sound, and those that were expected to soon be finished, were tested for ecological importance with LARCH (Alterra, 2005, interview 291005). LARCH and the ecological criteria within LARCH, thus, shaped policy decisions.

In addition, LARCH is extensively and systematically used by the Netherlands Environmental Assessment Agency (MNP), one of LARCH's largest customers (Verboom, 2006[12]). Amongst others, LARCH is employed for the redrawing of boundaries of the NEN and for projects related to the European Bird- and Habitat Directive and Natura 2000, a European network of protected nature areas. Since it operates in a changing institutional and political environment of increasing decentralization ranging from national to regional levels and towards decision making as a participative, multilevel, process with a number of stakeholders, the model is itself continuously being evaluated and further developed. LARCH has now also become an interactive tool that is used in these processes as a tool for deliberation and group decision support in provincial/local stakeholder consultative processes (Alterra, 2007). In this respect, it has also become a performative boundary object between diverse groups of stakeholders.

Whereas LARCH and its use are constantly in development, the modules remain relatively stable simply because it would be too expensive and time-consuming to adjust them for every new commissioned project, nationally or internationally. In some cases data is lacking to run LARCH in detail; whether there is funding for obtaining these data or whether LARCH should work with rougher data is then a decision that needs to be made. In this respect, the model often directs the research and the results which lead to policy decisions. Policy questions may be adjusted to the possibilities of the model. In assessing ecological corridors and projects related to Natura 2000, LARCH helps to shape what nature will look like in the future and this can be regarded as Barnesian performativity. The use of LARCH has been classified as having a middle to high policy risk because of the money involved and the large societal concerns that are at stake (Jansen, et al, 2004): if the corridors may not have the predicted effect or even a counter effect, the reputation of the Ministry of LNV and its relation with stakeholders could be at stake.[13]

Both models legitimate decision making and have influenced both the context and form in which certain knowledge is constructed and used for policy processes. They have become constituents of the (political) reality by selecting, providing, and structuring information that then sometimes became an 'obligatory point of passage' (Callon, 1986) in decision making processes. In this, they have also become disciplining tools: they legitimate the use and form of certain data over others, they determine what research and policy questions can be (easily) answered and which ones can be left out. More importantly, once models have been developed and are used for the making or evaluation of policy, they often result in routinized patterns in research and, moreover, in policy making, and therefore, also in the coordination and demarcation of science and policy. Yet, they do this in different ways with different consequences.

Conclusion

Models play an increasingly important role in the use of scientific knowledge for policy making processes. This paper

argues that it is insufficient to only concentrate on the boundary object character of models to understand this ever-increasing role and stresses that also the performative character of models needs to be investigated. Although the notions of performativity and boundary object have different origins and a tension seems to exist between them, connecting these notions facilitates a more complete understanding of the role of models in policy.

This paper has demonstrated that both the care and the LARCH model can be regarded as boundary objects *and* demonstrate several levels of performativity. These levels do not necessarily co-exist at all times. Whereas both models show some form of Barnesian performativity, it can be argued that the care model became increasingly performative with regard to this stronger form of performativity. In contrast, LARCH is used in a more varied range of settings. In its increasing function as a tool for deliberation and group decision support, the generic and effective forms of performativity are dominant. On the other hand, its role in deciding which ecological corridors will be established can be classified as a feature resembling more closely Barnesian performativity.

Models can be regarded as a special kind of boundary object in their performative nature. Models "commonly exert a compelling persuasiveness; they are designed to look 'real'–particularly to those beyond the model-constructing community" (Yearley, 1999: 846). In addition, models incorporate some aspects of what Fujimura (1992) calls standardized packages, e.g. theory and standardized tools. Both the care and LARCH model have become relatively stable objects and are strongly embedded in both the research (CPB and Alterrra) and the policy context. They have been used as policy tools for a long time, which has led to routinized patterns in both research and policy in which their function as a boundary object is crucial. This makes it increasingly difficult to reconstruct them. These features and their embeddedness make their performative features stronger *and* do not diminish their boundary object character.

By illustrating and making explicit that performative science-based models go beyond their role as boundary objects, we aim to obtain a better understanding of how models shape practices, social worlds and lived realities. Moreover, in order to acquire a more thorough understanding of how models shape our (policy) worlds in an era in which models play an increasingly important role in the use of scientific knowledge for policy making processes, we contend that a more systematic investigation of the performativity of models as boundary objects is needed. A next question would be to more extensively explore the differences and tensions between the two concepts during the construction of models, and to focus on the tension models bring with them between remaining a boundary object that coordinates between relatively stable worlds and becoming a performative object that changes the social worlds.

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Notes

[1] An exception is a study by Mattila (2005) that discussed the elements of interdisciplinary modeling projects that provide for such insights; the dynamic relation between expertise, collaboration and the research object in which scientific development and mutual learning can take place.

[2] Evans (2000) notices an absence of this particular way of using models in his case study on UK economic policy. He states that the 'translation' of the needs of policymakers into economic models depends on whether economic agents accept the 'roles' that are designed for them in macroeconomic models. In this sense, models function as legitimations of political and moral theories about the world. Increasing the plurality of models allows for discussion about underlying assumptions and the actors and institutions one wants to involve, instead of producing some sort of self-fulfilling prophecy machine.

[3] In order to ensure the anonymity of the interviewees, some interview material is coded.

[4] The analysis of the data was done based on a research protocol that was developed for the Rethinking project in which seven researchers participated.

[5] The SCP focuses on social and cultural issues in Dutch society, and its two-yearly Social and Cultural Report is a key publication in long term strategic planning (Trommel, 2003). The RIVM plays a similar role concerning both environmental and health issues, commissioning for example the four-yearly Public Health Future Prospects and the Environmental Outlook (RIVM, 2002). The CPB has an authoritative position in the Netherlands when it comes to economic policy analysis and economic predictions. The government relies on CPB estimations of economic development and adjusts its policy making in economic, financial and most other policy fields on these estimations. Together they were fit to develop a new model for the assessment of policies for the healthcare sector.

[6] The project secretary was also responsible for the progress of the project, as well as for secretarial support in meetings with the scientific committee.

[7] Within economics this is known as a major challenge that many have tried to solve. It also addresses the question how to accurately perform econometric science to answer policy questions. One of the more famous econometrists that performed good work in this field is the Nobel prize winner Heckman.

[8] The team used to be called 'Spatial Models' but is now 'Ecological Models and Monitoring'. This team discusses how models can be coupled, but further model construction often takes place in project teams which work on specific applications of the model. They may adjust the databases with which the models work for a specific application of the model.

[9] These authors investigate performativity in relation to economic models and theory in economy (Callon, 1998; MacKenzie, 2007; Garcia, 2007; Zuiderent, 2009).

[10] This event is well described by Garcia-Parpet for the Soulogne strawberry market (Garcia, 2007).

[11] Since 2000 the Government has worked on the introduction of a new policy program for the governance of health care, based on the notion of managed competition by Enthoven (VWS, 2001), which was introduced in 2006. Alongside, the CPB published a revised version of the model in 2006. This version is better suited to deal with the assessment of policy measures taken within the market oriented care sector, and for the tri-annual release of the health expenditures prognoses reports.

[12] In 2008, the MNP together with the Netherlands Institute for Spatial Research (RPB) became the Netherlands Environmental Assessment Agency (PBL).

[13] Mackenzie distinguishes a counterperformativity as well when the use of models, or theory, makes processes in reality look less like their depiction by models, or theory. In both events, however, the use of theory, or a model, intervenes in the social world to such extent that it changes that reality.

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