Jasmin Kominek

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Jasmin Kominek [a,b]

[a] Research Group Climate Change and Security, KlimaCampus, University of Hamburg, Hamburg, Germany
[b] Department of Social Sciences, Institute of Sociology, University of Hamburg, Hamburg, Germany

Correspondence to J. Kominek:
Tel. +49 (40) 42838-7719
Fax +49 (40) 42838-7721
eMail: jasmin.kominek@zmaw.de

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Abstract

Climate change is a global phenomenon and it is increasingly attempted to discuss and solve related problems on a global level. But this increasing emphasis on, and empowerment of, global institutions can have side effects on local power structures. The following analyses indicate that the increasing global institutionalization can lead to an intensification of local conflicts around the world. This conclusion follows from an application and extension of the concept of path dependency. Examples are given of how local self-reinforcing structures can be used in a positive way to smoothly trigger an increase in mitigation and adaptation capacities.

Introduction

Decisions on climate policy at the global level affect the options for policies at sub-global levels. If, for instance, it was decided at the *global* level that all countries around the world should build more nuclear power plants, *national*, *regional*, and *local* social structures would be affected as well. On the one hand, large building companies, energy groups, and related political parties might use the legitimization of such policy to push their own interests and to increase their revenues. On the other hand, opposing groups such as green parties, village groups that are potentially affected by radioactivity in the vicinity of a newly built nuclear power plant, and civil society groups that worry about a possible contamination of the environment and about increasing security risks would probably join large demonstrations, and organize actions to blockade construction work. The actions of one of the coalitions in this confrontation can cause the opposing groups to tighten their positions and to strengthen their power structures and vice versa. In this scenario, a recursive self-reinforcing phenomenon is triggered and enhanced by actions at the global level. The described scenario demonstrates that decisions reached at the global level can influence local structures. The importance of the global level can also be extended to political dynamics prior to decisions, e.g. when these provide legitimacy for local agent's positions.

The link between the global and the local level can be described using an extended path dependency theory. This approach is useful to analyse how dynamics are triggered and increased within existing social structures in a self-reinforcing way. Content independently, certain structural dynamics can be described that shape people's behaviour. These are also relevant for considering side effects of the policies responsible for climate change, as well as of those policies for its prevention, mitigation, and adaptation.

Based on a description of the different steps of a problem-solving process, first a formal scheme is presented in this paper. This scheme distinguishes between the overall problem-solving process, situational analysis, a step of modelling and evolving strategies, and a last one of situational intervention. Using this structure, in each of this paper's sections one of the steps is explained in greater detail and the theoretical background is presented, expanded and developed. This leads to the concluding hypothesis that global climate policy can lead to an intensification of local conflicts around the world.

As political negotiators are likely to be affected by path dependency, this phenomenon is defined and its theoretical background explained in the section considering the overall problem-solving process. In the subsequent section, the theory is expanded to draw conclusions from the macro level phenomenon for micro level agents and to assess possible changes in individual decision-making resulting from path dependency. Next, a formal multi-agent model is presented to show that with increasing effects of path dependency, the variance of the actions by people affected tends to be reduced. Furthermore, people increasingly see only the narrowing set of possibilities as the basis for their actions. Finally, situational intervention and the implementation of chosen strategies are discussed.

Examples are given of how the self-reinforcing character of path dependent processes can be deliberately used to trigger dynamic action processes that are directed at mitigation and/or adaptation. These processes are chances to positively apply knowledge on social dynamics by enhancing non-conflicting measures. Meanwhile, the perceived or actual narrowing of options through political processes at the global level in turn generally exacerbates national and local conflicts, consequently leading to their amplification. A conclusion briefly summarizes the insights gained from the path dependency perspective and underlines the necessity to include it in considerations of global climate change-related policy.

Path dependency is a concept used in many areas of social analysis. It can be expanded to explain micro level behaviour as well as the dynamics of the interaction of agents on different levels (Kominek 2009b). This chapter aims at applying this approach to the question of climate-change-related actions. The particular question addressed in this chapter is the effect of path dependency on conflict. It is argued here, that there are structural dynamics, described by path-dependency theory, which can lead to an intensification of already existing national and local conflicts triggered by global climate politics. This provides the theoretical underpinning of the scenario used in the opening of this chapter.

The importance of path-dependency theory is often questioned (Liebowitz/Margolis 1995, Alexander 2001). It can be argued, for instance, that revolutions can break macro level structures and politicians and societies may suddenly change to completely different actions. However, contrary to this argument it can be argued that basic behavioural routines can survive a revolution and can actually reinforce structures in an even more powerful way (Kominek 2009a). Analysis of how path dependency affects a single agent at the micro level helps us understand such findings. These considerations are presented in the part of the situational analysis and interpretation.

1. The overall problem-solving process

Climate change-induced degradation of freshwater resources, climate change-induced decline in food production, climate change-induced increase in storm and flood disasters, and environmentally induced migration are the four “typical causal linkages at the interface of environment and society, whose dynamic can lead to social destabilization and, in the end, to violence” (WBGU 2007:2-3). Knowing these facts, a high willingness to prevent climate change and mitigate negative effects on society and the environment can be assumed.

However, a person living in a rented apartment cannot easily exchange wooden window frames or switch the heating system to reduce carbon emissions. One can hardly estimate when buying an apple or a T-shirt how much emissions or water were spent on its particular storage, production or transport. And an agent could try to reduce her power usage, but embedded in social networks the necessity to stay available requires a certain minimum use of electronic devices in the modern world. Thus, even though we have discovered that climate change occurs and we may have developed preferences how to reduce carbon emissions or emissions of soot aerosols and how to conserve freshwater, these preferences are to some extent kept from directly influencing our actions by institutions or social structures surrounding each one of us. This behaviour can be described as a path dependent behaviour in contrast to a substantially rational one, which would imply reflecting and optimizing our preferences and acting accordingly. If even everyday behaviour of any given single agent needs to be described in terms of path dependency, every agent involved in negotiations of climate change policy, each agent who is affected by climate change-induced disasters, and the ones who try to intervene occurring situations, are likely to be to some extent influenced by the surrounding structures instead of being driven only by rational preferences. Therefore, the problem-solving process itself needs to be considered in detail to gain an impression on unintended structural side effects and to increase the chance of avoidance of conflict resulting from the effects directly related to climate change.

1.1. The formal scheme of a problem-solving process

For an analysis of the underlying mechanisms, the overall problem-solving process can be divided into a first part of analysing and interpreting the situation, a second part consisting of modelling and the deduction of strategies perhaps by use of simulations, and a last step of intervention in real situations through implementation of the strategy (Fig. 1).

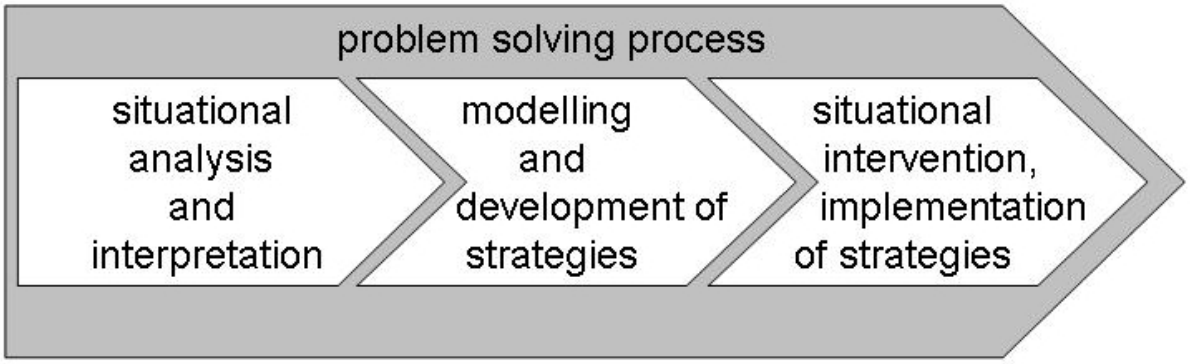

Figure 1: The formal scheme of a problem-solving process. A problem-solving process consists of four parts: the overall problem-solving process, in which political negotiations can occur, a part consisting of analyses and interpretation, followed by modelling and simulations. The final part is the implementation.

In each of these steps agents can be assumed to be present, e.g. debating on the overall problem-solving process, trying to decide politically who is most competent, who most affected, who is responsible and who needs to pay how much and when. In the situational analysis it is important to make assumptions about how the observed agents reach their decisions in order to be able to interpret their behaviour and the present state of social dynamics they are in. Who decides rationally about economic goals? In which situations might people affected by climate change panic and simply fight for survival? And in which situations does survival depend on decisions of institutionalized power structures instead of individual agents' other preferences?

The same decision behavioural assumptions that are stated above also matter in modelling and the resulting strategies, added up by again a not directly climate-induced affected level of political agents who negotiate strategies, in which micro politics are relevant as well. In the end, situational intervention is decided upon by political agents, and again agents are present in executing strategies in real situations in society, where e.g. climate change-induced affected agents live and act. Therefore, if all these agents are shaped and affected in their behaviour by the social structure surrounding each individual, what is the result?

1.2. Path dependency

If we consider the path of producing high emissions and another theoretical path of producing only low emissions, the combination of mechanisms that make us stick to the high emission path and prevent us from simply switching to the other (preferable) one can be described in terms of path dependency.

Path dependency is a phenomenon that basically implies that present decisions depend on former ones or events made in history. On a macro perspective, these sequences of decisions and resulting actions are lined up forming a path. There are different areas of society, technology, or science in which path dependency can be observed. Even though some authors argue with respect to technology that the selection of some technologies opposed to other options is due to efficiency criteria and actually the result of perfect market selection mechanisms, in other fields such as in politics it is less denied that path dependency occurs and it is likely to manifest paths that prevent correcting mechanisms and thus lower the chances for different actions in the future (Liebowitz/Margolis 1995).

In the case of the high or low emission paths in the previous example, bureaucracy and institutionalized processes can be made responsible for preventing the tenant of the apartment from switching to a lower emission path. Opacity prevents markets from selecting sustainable products to win in the case of consumption. And in the social network example, the dependency on quick information, frequent communication and global social networks as manifested habits and reinforcing social structures prevent agents from switching to low emission paths. To use existing theory and expand it later, first the current state of research on path dependency theory is outlined.

The QWERTY – keyboard, an example of the phenomenon of path dependency

The notation of path dependency used in a sociological context was originally coined in economics (cp. e.g. Beyer 2005; Arthur 1989, 1994; David 1985, 2000, 2007). In a narrow sense, a process is considered to be path dependent if it is a self-reinforcing process with the potential for a lock-in (e.g. Sydow/Schreyögg/Koch 2005, 2009). A broader understanding allows the use of path dependency more as 'history matters', which means that past events influence present and future actions (going back to Arthur 1989; David 1985). The most popular example to understand and describe path dependency is the case of the QWERTY-keybord. Present (English language) computer keyboards (still) usually have the keys

QWERTYUIOP in the topmost row of letters, which is why they are called QWERTY-keyboards. Thus, the question can be asked why it appears to be resilient against change and why the keys were placed on a QWERTY-keyboard in the past.

The key placing in exactly the number of rows as we know today resulted from different optimization processes to prevent former type bars from clashing and jamming. But the final key placing of the letters in the topmost row occurred due to the fact that the first production line of typewriters was called TYPE WRITER and the company wanted their salesmen to be able to quickly type the brand name in product presentations (David 1985). So it was assured that the entire letters of TYPE WRITER could be found in the topmost row. And even though it is long since those reasons have disappeared, today's keyboards look quite the same although there are different alternatives available to improve keyboard ergonomics or completely change the way of entering text in an electronic device. The QWERTY-keyboard still is widely spread, used, bought and applied even on smartphones that do not even have keys at all.

"The agents engaged in production and purchase decisions in today's keyboard market are not the prisoners of custom, conspiracy, or state control. But while they are, as we now say, perfectly "free to choose," their behavior, nevertheless, is held fast in the grip of events long forgotten and shaped by circumstances in which neither they nor their interests figured." (David 1985: 333)

Applying this summarized description to the case of high or low emission paths, you get statements such as the following: While apartment leasers, consumers of apples and T-shirts, and members of modern global society involved in social networks are *free to choose*, their behaviour is shaped by former events manifested in the structures surrounding them that were shaped by former circumstances, in which carbon emissions and climate change did not figure.

Debate of the concept of path dependency

Pierson (2000) summarizes the characteristics of path dependent processes (relating to Arthur 1994: 112-3) with the terms unpredictability, inflexibility, non-ergodicity, and potential path inefficiency. At the beginning of a path its final state cannot be predicted, in the lock-in it is difficult to change paths, small events at the beginning of the path may have large effects through positive feedback mechanisms, and "in the long-run, the outcome that becomes locked in may generate lower pay-offs than a foregone alternative would have." (Pierson 2000: 253). While it seems difficult to actually use a concept based on processes that are characterized as unpredictable, it is used in various ways.

In organizational sciences Sydow, Schreyögg, and Koch use the narrower notation of path dependent processes, which characterizes them as self-reinforcing processes with the potential for a lock-in: They suggest a 3-phase-model to describe a path dependent process, where in phase 1 contingency is present, in phase 2 self-reinforcing mechanisms more and more restrict actions until the lock-in occurs and action changes at most incrementally in phase 3 (Sydow/Schreyögg/Koch 2005, 2009). Relating to various fields of science, Beyer (2005) lists seven mechanisms that can be characterized as containing logic of assuring continuity. And Page (2006) analyses different clustering of mechanisms that affect whether processes become path dependent and assesses characterizations of path dependent processes in mathematical modelling. Based on stochastic processes, Page expands Arthur's models.

In political sciences, Pierson (2000) states that every institution is path dependent. In contrast, Alexander (2001) argues that politicians do not decide entirely rationally, so the economic definition of path dependency is not applicable without restrictions. On the other

hand, Mahoney (2000) transfers the context of path dependency to social sciences and points out that the phenomenon cannot be sufficiently explained with economic approaches like utility theory, because it is a paradox trying to explain inefficiency with a concept that does not allow any other result than efficiency.

North (1990, 2005) describes institutions as locked-in (and thus in terms of path dependency) when they can be only incrementally changed by organisations. And also at a theory-combining level, processes of institutionalisation can be described as self-reinforcing processes and thus in the terminology of path dependency (Kominek 2009a, referring to Giddens 1984 and Berger/Luckmann 1979). Liebowitz and Margolis (1995) present a characterisation of path dependency phenomena consisting of three categories differentiated by the degree of inefficiency they produce, but they still argue whether the QWERTY-keyboard is actually an example of inefficiency, and thus market failure. Because, if the QWERTY-keyboard was the best solution for agents' local need the market would prove well working in selecting the QWERTY-keyboard as dominant technology.

All these approaches have in common that they more or less describe path dependency by focusing on the phenomenon: They try to discover paths on which path dependency acts in empiricism, characterising path dependency using the attributes *unpredictability*, *inflexibility*, *non-ergodicity* and *potential inefficiency*. They also distinguish paths in phases, cluster mechanisms around them, compare and cluster path dependent phenomena and try to describe them with mathematical models. But as Garud and Karnøe (2001) point out, although agents are central to the process of path dependency, a theory of agency is still not available to characterise them.

Thus, if path dependency shapes social structure and shapes agent's actions through institutions, what would happen if a climate change-induced disaster destroyed institutional infrastructure or if a revolution broke paths and changed its contents? And what if agents just deliberately acted differently?

Even if social structures were suddenly blockaded or vanished at the institutional (macro) level, the previous impacts path dependency had on the decision-making processes of each affected agent (at the micro level, as deduced in the following sections) would still shape their behaviour. That way new path dependent processes and structures are likely to be created (Kominek 2009b) through the back door, which would even more intensely influence the involved agent's action (due to primary-like socialization, Kominek 2009a). Of course, as long as agents do not act entirely path dependently, they should be able to deliberately act differently. Still, from the mere fact that paths actually affect agents in their decision-making and shape their behaviour to an assumable degree, some predictions can be derived.

2. Situational analysis and interpretation

As just discussed in detail, one characteristic description of how path dependency affects agents' behaviour is that their decisions and actions are shaped by past events which did not regard their present preferences (David 1985: 333). While for example politicians debated whether it was useful to rebuild New Orleans after Hurricane Katrina in a more secure way to prevent future disasters, enrich the lifestyle of the inhabitants of the city, or design the new houses in a more appropriate way, local residents acted in an obvious way: "The actual decisions and rebuilding undertaken to date, the so-called "facts on the ground," clearly demonstrate the rush by the residents themselves to rebuild the familiar." (Kates et al. 2006: 14659). Trajectories of recovery can be identified that predict that a recovery generally follows the pre-disaster trajectory, with the disaster even accelerating previous trends (Kates et al. 2006: 14658).

When you look at the current situation, interpret the agents' actions and assume that path dependency is affecting their behaviour, the present goals of these actors cannot necessarily be deduced, because instead of thriving to reach their goals, they may more or less simply stick to paths. Just the same, if asked they may answer that they actually feel free to choose what they want to do and they are happy with what they do all the time anyway. And they perhaps could even name a worse alternative to justify their action. One example could be that imported food is preferable to local food because local storage and cooling over time would produce more carbon emissions than an optimized transportation system from abroad. Or the other way round, local food could produce fewer emissions because transport distances are shorter, even though it might happen that each agent drives to the nearest farm by car. Other agents may not be happy with what they do and perhaps just do not feel free to choose differently, as they do not see any viable alternative for them. A suitable example for this is the wooden window frames or the heating system, which a tenant of an apartment cannot decide upon by herself.

Furthermore, if asked to state their individual goals, e.g. to reduce carbon emission, it can be difficult to deduce from the agents' answers whether the mentioned goals are more justification or real basis and evidence for rational choice. Some agents might even answer that they do not have any special preferences or goals or that they do not know them. This may be true in some cases because when choosing between perhaps only one or two obvious alternatives it is not necessary to have a large variety of goals in order to pick one particular path. Therefore, more interesting and relevant than analysing the agents' goals and motivations is to analyse how agents' behaviour is influenced by surrounding paths.

2.1. Ideal type path dependent[1]

So, what exactly happens if an agent is affected by path dependency, what does it mean for an agent to decide path dependently? Because path dependency cannot be entirely explained by utility theory alone (Mahoney 2000), it can be concluded that a path dependent decision cannot be described as substantially rational (Simon 1976) or as an 'ideal type rational-calculative' one (Esser 2005). This is the fact even though actions can usually be rationalized, which means that they can be explained ex post in terms of a rational decision as to why e.g. one T-shirt is better than another. While sustainability arguments just cannot be monetized or are weighted with a coefficient of zero and consequently do not show up in the final result of the observable action. So an agent's rationality is bounded (Simon 1976) by the individual horizon and the surrounding environment evokes decision frames that shape the resulting action.

Esser (2005) describes a model of frame selection as an expansion of classical rational choice theory. In this chapter, a similar argumentation is presented using fewer assumptions. Nonetheless, they are sufficient for subsequent analyses, resulting in an 'ideal type path dependent' that can be used as basis for a multi-agent agent based model that describes agents' behaviour when optimising emission reduction or simulates local agents' behaviour with regard to their reaction to climate change-induced events.

The new model frame

If a path can be monitored at the macro level, there must be some similarity in the observed actions that makes them appear as if they were lined up forming a path. This similarity implies that some part of actions taken stays the same over time, which means it can be described in some form of constancy or routine. So living in a rented apartment one routine

[1] The term *ideal type path dependent* is deduced from the terms *ideal type rational-calculative* and *ideal type automatic spontaneous* (Esser 2005, cf. Kominek 2009b).

could be to simply use the existing heating system instead of fighting arguments each day to change the heating system, before warming the bathroom in the morning.

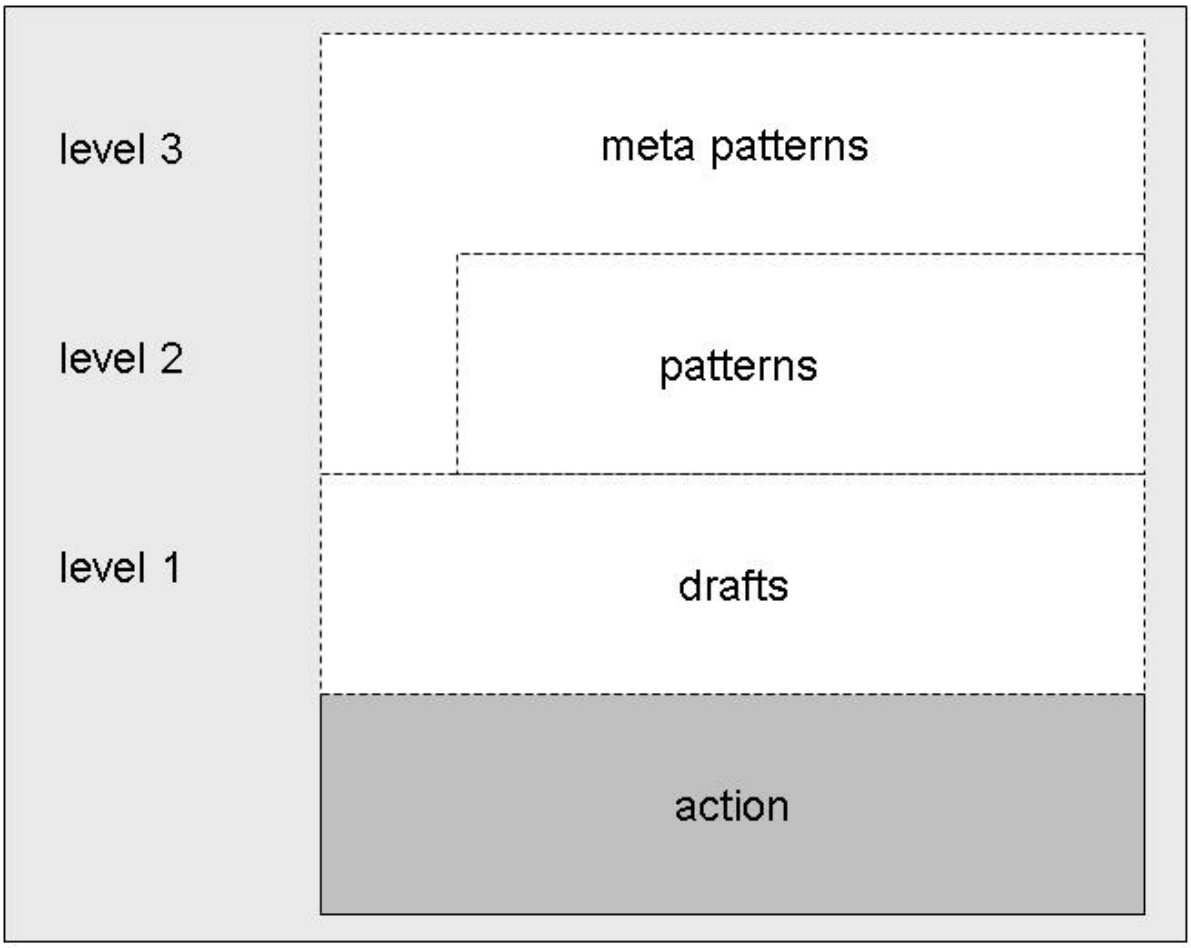

Figure 2: Model framework of the new action model. The decision process can be separated into different levels of consciousness that can be applied. The process is initiated on level 1. Levels 2 and 3 are only used if necessary. The dashed lines indicate that no further chronology is fixed, but contents of all three levels could be combined (Kominek 2009b).

In the following model, this least-effort-principle is not implemented as a deliberate rational choice, which would also be possible. It is even applicable on a more basic psychological level such as in social psychology when scientists describe how the brain works. In social psychology (e.g. Chaiken/Trope 1999) it is usually assumed that a real executed action is preceded by an activated cognitive action draft. Therefore, level 1, the level of drafts in the model frame (Fig. 2), is the level of action drafts, on which exactly one draft needs to be chosen and activated prior to the real action. To describe an automatic-spontaneous action with this model frame the lower two rows would be sufficient (Fig. 3). The action decision-making process is therefore initiated on level 1, the level of action drafts. If more than one draft can be chosen that can be considered to be comparably practicable or if no single draft can be chosen as perfectly matching on this level, a further decision process is necessary to solve this inner conflict (cf. Chaiken/Trope 1999). Consequently, one model assumption is that only when an automatic-spontaneous decision is deemed impossible or infeasible, other decision criteria are added to the decision process and thus a decision process different of an *ideal type automatic spontaneous* is started.

To map whether such a decision process is different from the ideal type automatic-spontaneous one, two more levels are added to the model frame, level 2 and level 3. Level 2,

the level of patterns, contains decision criteria such as moral values, goals, norms, abstract models, prejudices, other knowledge or information that are evoked, rejected or enriched when considered in decision processes. Level 3 contains meta-patterns that control the inner process of decision making. With regard to the level of inner stress, routines or agent individual decision making, they let the decision process run e.g. shorter or more slowly, expand or flatten it, make it more or substantially less rational or controlled by anxieties, goals or values.

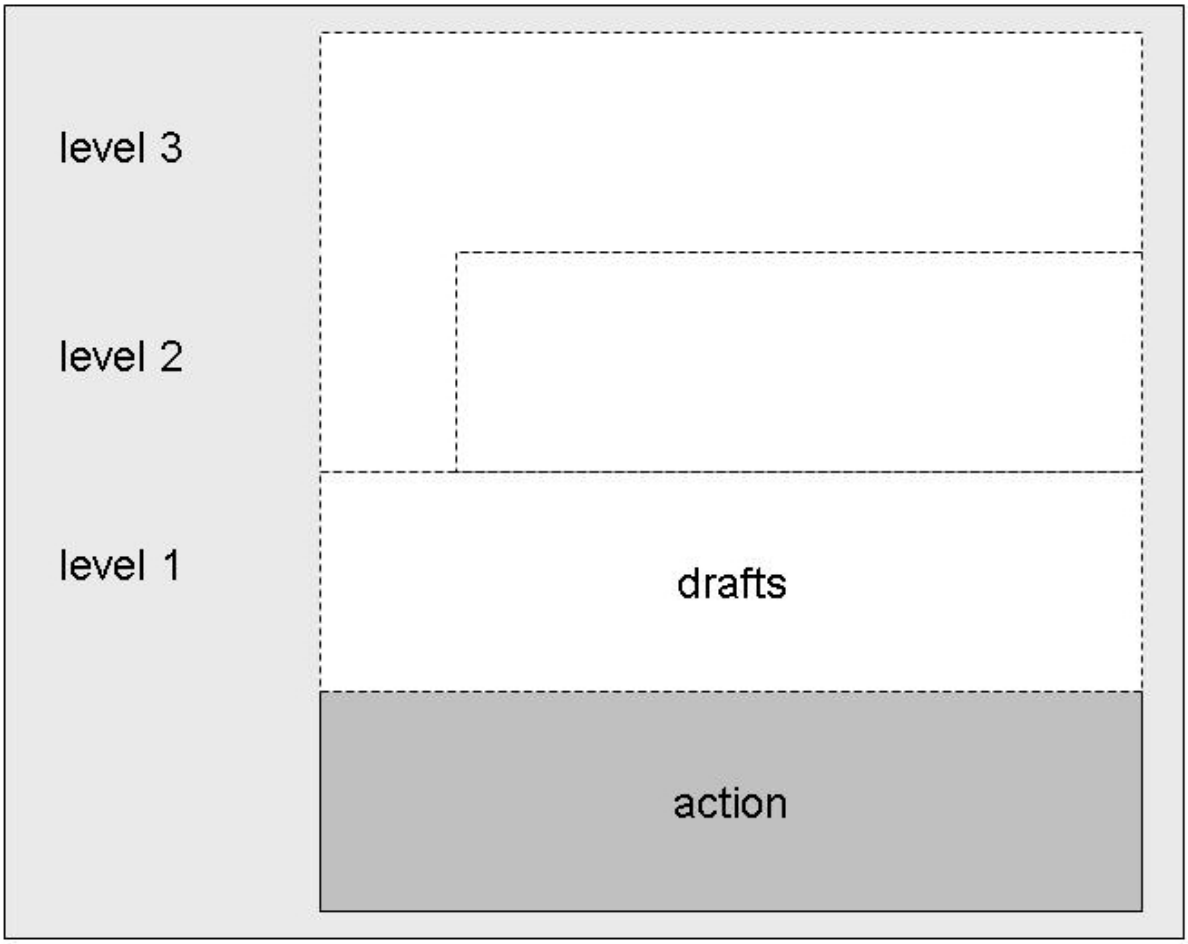

Figure 3: Decision framework of an ideal type 'automatic-spontaneous' agent. Only the level of drafts is necessary for action. Prior to action, one particular action draft must be selected to be executed (Kominek 2009b).

However, as the dashed lines indicate, the use of levels can be interactively flexibly combined.[2] The differentiation between levels 2 and 3 only allows a clear arrangement and indication of two fields of analyses, one concentrating on the content (level 2) and one on the process (level 3). These two ways influence the decision process and possibly also the decision result and therefore have an impact on the resulting action. Consequently, the suggested model merely offers a framework for subsequent analyses.[3] Using this framework, the *ideal type rational-calculative* can be described (Fig. 4).

[2] This is different from Esser's model of frame selection where a clear chronology is assumed, in which different levels are passed with steps of a modus selection in between. In a modus selection the agent decides more or less consciously whether the partial decision on the next level would be chosen in an automatic-spontaneous or rational-calculative way (Esser 2005).

[3] It is attempted to use the lowest possible number of assumptions, particularly fewer than in rational choice models.

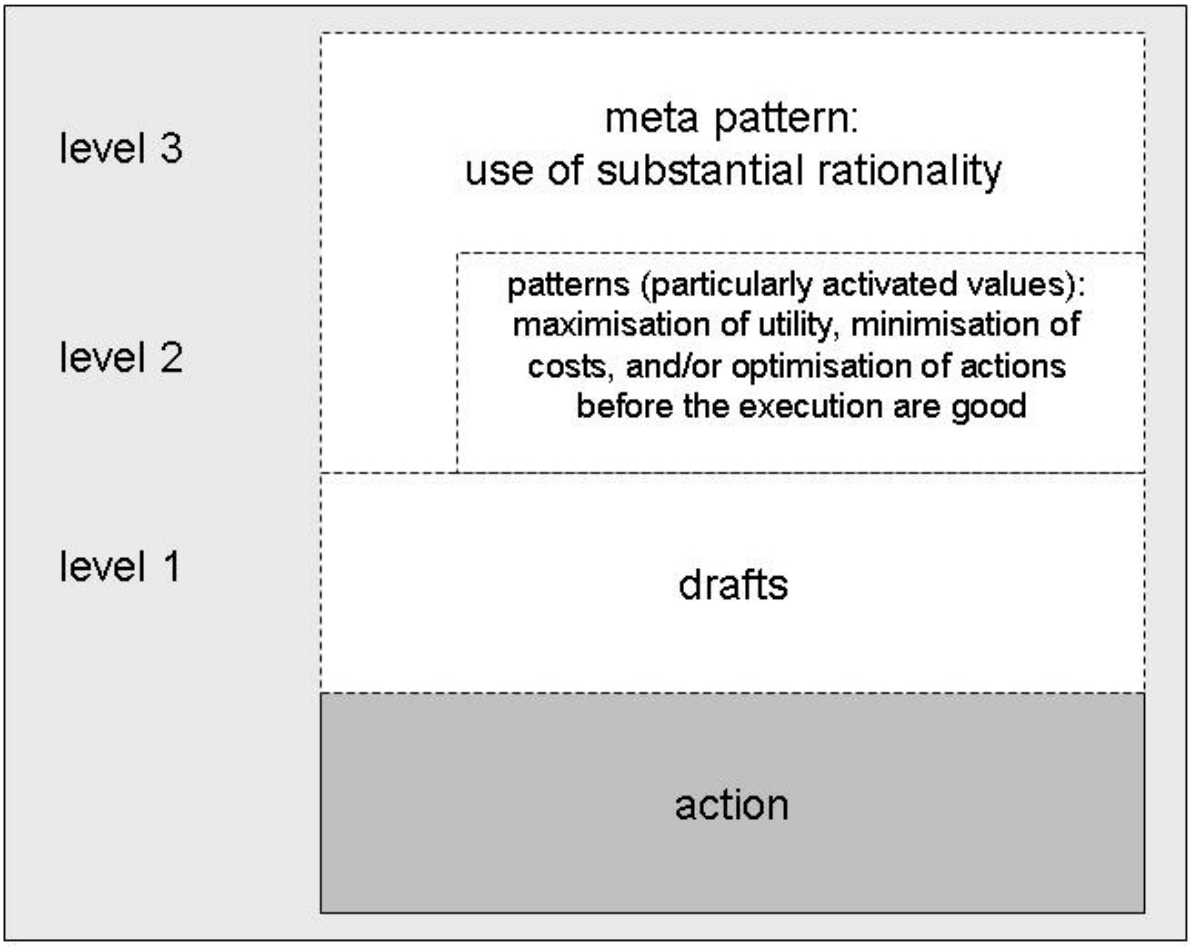

Figure 4: Exemplary decision framework of an ideal type 'rational-calculative' agent. If an agent chooses rationally, the meta pattern of using substantial rationality is activated and the decision process reaches conscious optimizations of available information. There is a choice between the various patterns to select the optimal draft for execution and subsequent action (Kominek 2009b).

Deductions from the macro level path to micro level decisions

Emission paths of high or low rate are only observable at the aggregated macro level. But according to the general path dependency theory it is not possible to predict outcomes before the lock-in. And in the state of a lock-in any action is practically stuck and therefore predictable, it cannot be changed flexibly anymore. Therefore, it is of particular interest to deduce the single agent's decisions at the micro level from macro level information in order to predict dynamics that can then either be prevented, changed or strategically intervened with.

Whatever causes similar actions that can be understood as the following of a path, the way of acting like that becomes more and more a habit. It is possible to shorten a decision process by merely following a habit without thinking anymore (on levels 2 or 3), or evoking further (or any) decision criteria. Because of the least-effort principle (in social psychology; Moskowitz/Skurnik/Galinsky 1999), this shortening of decision processes is what occurs if a path is followed for a longer period of time. Thus, the more path dependent decisions an actor reaches, the more his process of decision-making is just a matter of following some routines or rules because already the process of having and applying habits or routines again becomes a habit (according to the least-effort principle; Moskowitz/Skurnik/Galinsky 1999). Of course, this is a very detailed description of a self-reinforcing process, because in the

described way a habit or routine gets reinforced. But this psychological analysis is necessary to reach the conclusion that an ideal type path dependent can be used comparably to an ideal type rational-calculative to expand multi-agent models.

What happens when this agent who acts path dependently is confronted with a previously unknown situation, e.g. if the tenant of an apartment smells the emissions of her switched on heating system in the bathroom? The agent either simply continues to follow the same routine she always uses: to switch the heater on and to leave it on as long as necessary. Or the agent does what she usually does when confronted with a new situation (which is almost like a routine on level 3): she turns the heater off again or leaves the room to return to a familiar situation. Alternatively, the agent needs a new routine to match the new situation: e.g. she could open the window. A quicker (or more successful) strategy for an agent than to generate a new routine for herself is the adaptation of (successful) routines, rules, and standards from other decision instances. E.g., she asks a neighbour how to deal with the smelling heating system.

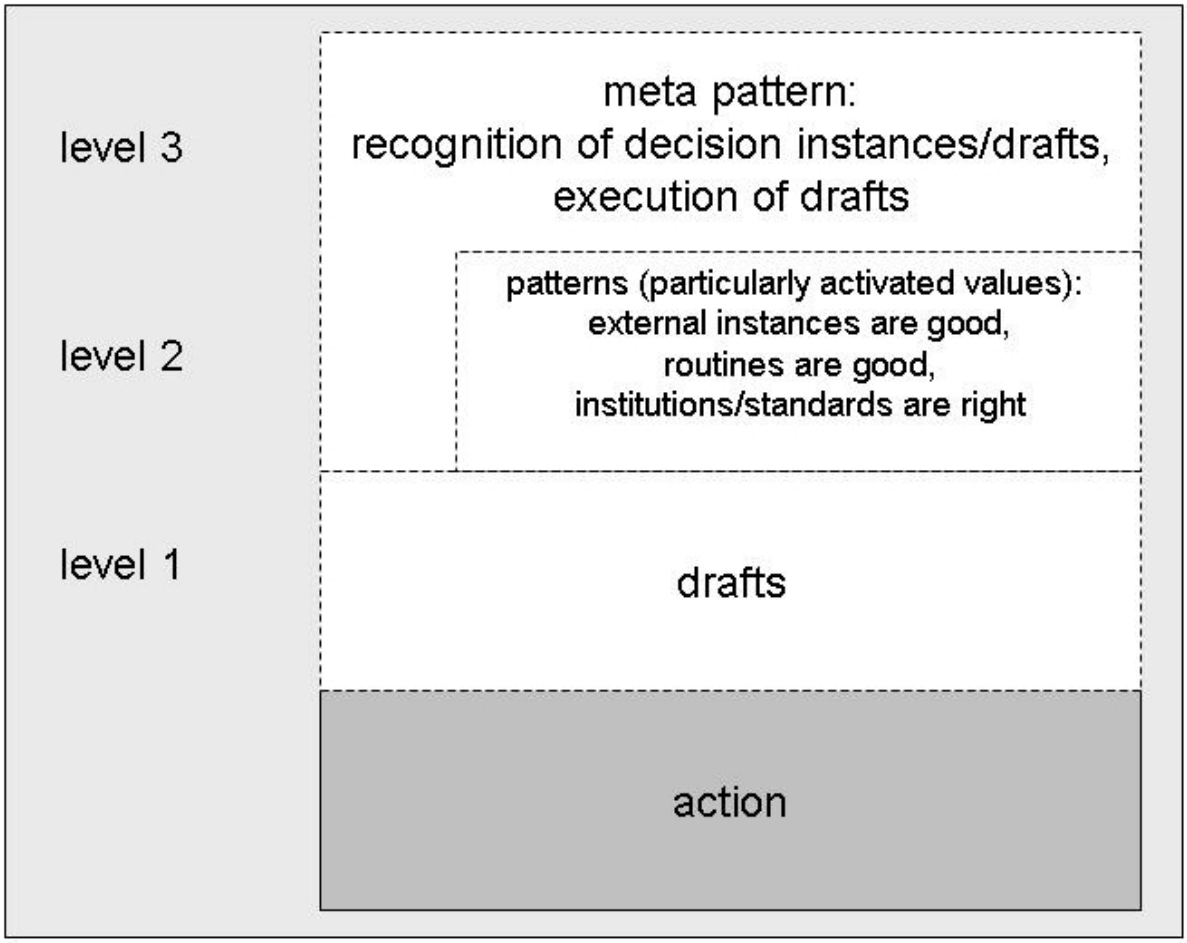

Figure 5: Components of the decision-making process of an 'ideal type path dependent' agent activated (and created) by path dependency. The behaviour of following individual experts can be described as the recognition of decision instances and the execution of a draft. If level 3 is reached in the decision-making process it refers back to levels 2 and 1 with the advice to follow routines and institutions and more or less simply execute the drafts. The final selection of the action draft occurs in a routine way (Kominek 2009b).

The neighbour might suggest calling the custodian as an expert to fix it.[4] So again, according to the least-effort principle, the agent more and more tends to prefer this external adaptation of routines instead of generating them herself. This manifests itself in the inner decision process and in the decision criteria. It is even quicker than adapting full routines to merely adapt drafts that only need to be executed, as it is not necessary to remember to always immediately call the caretaker when there is trouble with the heating, but the neighbour may suggest this action again if asked another time.

It can be concluded that agents who encounter a new situation, like the one that is stimulated by climate change, are likely to rely on others in their behaviour, especially on locally available individual experts (Simon 1983). The likelihood for this behaviour depends on the intensity in which path dependency has previously affected the agent, e.g. through local social structures, routines, tradition or culture. As a consequence of this analysis, an *ideal type path dependent* can be defined. This means that the more an actor tends to decide and act path dependently, the more his decision-making processes tend to resemble ideal type path dependent behaviour (Fig. 5).

3. Modelling of evolving strategies

Now the characteristics of an ideal type path dependent can be used to model scenarios or predict behaviour with the accuracy of people being affected by path dependency. Related to this topic, it can be stated that if global climate policy increases the institutionalization and thus the affect of path dependency on single agents (Kominek 2009a), it reinforces their tendency to act like an ideal type path dependent. So, what social dynamics or group behaviour would result?

The following example describes how the ideal type path dependent can be included in the expansion of an agent-based multi-level model to make predictions. The more the applied decision processes resemble those of ideal type path dependent, the more the considered agent tends to follow others instead of computing complex solutions himself, e.g. migrating where others migrate when affected by climate change-induced flooding or water scarcity, or fighting whom the others fight if local experts also do so. Such results, stemming from behaviour of ideal type path dependent agents, can be modelled. And then, using the probability of these agents being affected by path dependency, their action can be predicted. Simulations of social dynamics resulting from behaviour of ideal type path dependent agents then can be used to develop and optimize intervention or even prevention strategies.

3.1. A multi-agent model

To get an impression about group dynamics resulting from path dependency, some effects are now considered in a multi-agent model. The value-cost-system (VCX) model, a dynamic multi-agent interaction model, is used as base model, considering single agent action (Scheffran/Hannon 2007).

With some mathematical notation it can be described as follows:
Each action takes place in a system environment x, where costs C_i invested by agents A_i produce values V_i. Considering a given time t, the present system state would be $x(t)$, present costs $C_i(t)$ and the resulting values related to the same point in time $V_i(t)$. Then a group of n agents $A_1, A_2, \ldots, A_n$ can be considered, in which each agent acts through investing costs and receiving values.

[4] These effects can be monitored as complementary effects of path dependency or conformity tendency in e.g. organizational fields (Sydow/Schreyögg/Koch 2009).

If agents have target values V_i^* that they try to reach and that therefore serve as goals, they can be considered to learn in an adaptive way to approach their individual goals. When considering not only one point *t* in time, but stepwise action in a time sequence, the following point would be *t+1*, the subsequent one *t+2* etc. (while the previous one would be *t-1* and the one before *t-2* etc.). So if one assumes that this considered group of agents decides and acts rationally, one can let the agents compute efficiency rates and decide to take the most efficient cost investment to address their next-step target values $V_i^*(t+1)$.

This basic model then can be expanded and applied to model e.g. conflict situations as environmental induced fishery problems (BenDor/Scheffran/Hannon 2009), or arms races and international stability (Scheffran 2001; Scheffran/Hannon 2007). Furthermore, it can be used to model climate games, e.g. in the case of emission trading (Scheffran 2004). It is possible to calculate the implications of global emission goals for the regional or local levels, based again on the rationality assumption of each interacting agent.

Applying the previously described perspective of path dependency, the following behaviour of ideal type path dependent agents is considered in an expansion of the VCX-model and effects of path dependency are analysed.

3.2. Inclusion of a following behaviour in an expansion of the VCX-model

Assuming transparency within the considered group, a single actor A_j may look at choices other actors made during the previous time step and which results they achieved. Then she follows the actor whose action would have contributed most to reaching A_j's own goals. Thus, the decision rule is to do in the next step what the selected actor has done the step before. This decision rule can be formulated for each agent A_j as follows:[5]

$C_j(t+1) = C_{i_0}(t)$, where i_0 is defined as: $\left|V_j^*(t+1) - V_{i_0}(t)\right| = \min_{i=1..n} \left|V_j^*(t+1) - V_i(t)\right|$.

This particularly makes sense if costs are not only a monetary number but a complex combination of resources and the causal relationships between resource combinations and individual goals is not evident to the single actor. A consumer cannot exactly know which products or product combinations produce how much carbon emissions because companies may optimize some aspects of production such as transportation in various ways without mentioning data on the associated emissions. Instead of testing the complex situation for successful resource combinations himself it appears to be more appropriate for the agent to also use others' experience as described above, because other agents might have had better information about which products produce more emissions than others.

This way of decision making and acting can be described as a procedure that especially makes sense in complex real world situations when transparency between actors can be used to better address one's individual goals rather than just searching for the best action by trial and error oneself. This is particularly true if the positive or negative outcome for the individual is only recognizable long after the actual action as it is the case of climate warming effects due to major heating systems or industrialization.

However, following this procedure bears a strong limitation: While theoretically each thinkable complex resource combination may be used for a different next-step action to

[5] If the agent has a longer memory than just one period, the term $V_i(t)$ could be replaced by $V_i(s)$ whereas *s* runs through former periods *t*, *t-1*, *t-2*, … through each time period the memory lasts.

address an agent's goals, in the procedure mentioned above only the previously used combinations, i.e. an endless number, are allowed for determining the next action. If all group members decide following this kind of procedure, the number of action options can only be reduced over time and not expanded. And the group may end up all doing the same thing. This can be good as the resulting action may be the best action locally available for each single actor to address their individual goals, such as the reduction of carbon emissions or the survival of a drought or a flood. But compared to the infinite number of possible actions it is likely that the action chosen is suboptimal and cannot be improved over time if the agents stick to the described decision making procedure.

Of course, the procedure could be improved if an actor considered not only copying what she herself or other actors did before. She could use these actions as basis to compute new actions to best address her goals. Then there are still some limits as to how far she deviates from her former experiences or whether she sticks close to them, but at least new actions can improve group member's future actions. But if the action basis already consists of too many similar actions, even their combinations will remain similar (e.g. if all actors acted the same way the combinations of their actions would stay the same as well). Examples could be two types of preferred apples around the world that can be imported from different locations, or people who use the same type of heating system might use it in smaller or larger versions and thus somehow optimize the production of carbon emission per apple or heating system. But only depending on those two types of apples and the one style of heating system would be a narrow frame for optimization and it is likely that emissions could be reduced far more effectively if further actions were considered such as different local fruits or geothermic or photovoltaic solutions for heating.

3.3. Effects of path dependency

You can conclude from the former analysis that the more an agent is affected by path dependency the more his decision-making processes becomes similar to that of an ideal type path dependent. Therefore, the more he decides and acts in routines, or follows institutions, standards, or external decision instances when applying action drafts.

Returning to the multi-agent example of decision-making: The process of following others can be enhanced with institutions, standards, or abstract decision instances, e.g. by the mass of agents that can be followed. This way it is possible to deduce that the more path dependency affects an agent, the more he fits his decision making processes within the described multi-agent example. Thus, institutions, standards, and abstract decision instances can be added into the line-up of action options. This also holds for actions that oppose a standard or institution when mapping agent's behaviour. This may be quite a long line-up, but the single agent is still considered to be affected by path dependency. Therefore, whatever agent, institution or abstract decision instance he chooses as basis for his action, the reselection of this type of decision basis for his actions (as described before in an abstract sociological way) becomes again a habit or routine and further reduces his future action variety.

For example, if a consumer intends to reduce carbon emissions she may follow the standard of purchasing organically grown products (biologically produced goods), hoping that they were produced in sustainable ways. She would therefore buy a bio-apple or bio-T-shirt. Maybe a good friend of that agent would then tell her that the annotation 'bio-' does not necessarily include regulations on carbon emissions and that he or she would rather buy a locally produced apple or second hand T-shirt. A colleague may then say that mass-production tends to reduce carbon emission per product, because logistics and energy cycles can be optimised to a larger degree. And an NGO such as Greenpeace may suggest ignoring products of a certain company to punish it for unsustainable behaviour. So regardless of the decision instance the agent chooses as preferable (a bio-label, a personal

good friend, a colleague, the mass itself e.g. from nationwide statistics, or an NGO like Greenpeace) acting according to that preferable decision instance again becomes a habit.

The variety reduction of executed action is observable not only in historical recollections. Furthermore, the agent's points of view are more and more reduced as his actions are shaped by routines and when only a focus on a limited number of relevant institutions or decision instances is necessary for his action.

It can be concluded that even though theoretically an infinitely large action variety is available, path dependency more and more makes agents act only in a very limited range of actions, more and more believing these are the only actions they can take. Thus, global climate policy can lead locally to a reduction of action variety and therefore an increase in polarization. And in this context, even further conclusions on the strengthening of hierarchical structures can be drawn.

4. Situational intervention to prevent climate change and to enhance mitigation and adaptation; implementation of chosen strategies

4.1. Political structures evolve and are reinforced through path dependency

It can be deduced from the previous sections that as long as agents are affected by path dependency they more and more tend to follow routines or other decision instances in their actions and even tend to focus their attention on them and disregard other potential alternatives. This implies that the agents who follow others pass on their negotiating power and legitimations to their (collective) master. In the previous example the agent either follows the bio-label, the personal good friend, the colleague, the masses themselves, or an NGO. So whatever decision instance the agent chooses to let it influence his actions, by doing so he yields the power to influence his actions to that particular decision instance. The effects that follow from following that decision instance get additional authorisation via path dependency, and consequently that decision instance gets empowered to also influence the agent's future actions. That way, e.g. Greenpeace gets negotiating power, social networks get a hierarchical structure and traditions get reinforced. An increase of path dependency tends to reduce an agent's master options over time and manifests social structures as hierarchies. Therefore, path dependency tends to increasingly prevent agents from deciding rationally based on content issues and makes them followers within the social structures instead. Through path dependency micro politics increasingly matter more than contents.

Combined with the continued reduction of the considered range of alternatives caused by path dependency, path dependent negotiating processes are likely to end up in political conflicts as they only focus on a small range of alternatives in the political debate, resulting in the situation that there is usually only one particular view on an issue in each conflict party. Accordingly, global climate policy can reinforce national, regional, or local conflict structures and thus lead to an intensification of existing local conflicts around the world. And even further global conflicts could evolve as polarization increases and hierarchies are strengthened. But the knowledge of path dependent action does not only allow for conflict prediction, it also can help to more efficiently apply intervention strategies using local structures and self-reinforcing dynamics.

4.2. Situational intervention, examples of the implementation of strategies

If strategies evolve and are to be executed, situational intervention needs to deal with social structures and dynamics that result from path dependency and to some degree affect the agents' future actions. It may happen that social structures prevent direct intervention. E.g. political systems prevent monetary aid from reaching affected agents by spending it on other

priorities to enhance their own political structures, which could happen under some totalitarian political regimes.

Other effects may be self-reinforcing learning effects within populations on how to best cope with floods or water scarcity. The Dutch increase their dikes to adapt to a rising sea level resulting from climate change (Klein et al. 2001). Some coastal zones may use early warning systems to help people leave coastline houses in time to survive potential disasters (Adger et al. 2005: 1038). They may also expand the knowledge on how to quickly rebuild destroyed houses after a flood or move to more secure places in higher elevations. African pastoralists have the traditional knowledge to leave dry places and move on with their families and animals to oases where they still can expect to find some water (Berkes/Colding/Folke 2000). If all pastoralists share the same knowledge they will likely end up in the same places. Then the water may be not sufficient to support all people at the same time.

When people increasingly follow others, additional effects can occur. These could include cascades or mass migrations. People around the world watch TV or get told on the radio or by people who have travelled how other people live. And many would like to improve their living standard (e.g. India/Bangladesh). Others are affected by floods or droughts, lost their crops and/or homes (Kates et al. 2006). Depending on their own situation, families or villages either send out their most talented members to earn money elsewhere to ensure the survival of the collective (e.g. Mexico, cf. Lindstrom 1996), or they all migrate together if e.g. their entire land is lost (e.g. Pacific Islands, cf. Barnett 2001). And also in less affected regions democratic behaviour can evolve and result in conflicts between parties that blockade early prevention although technology and capital would have been available (Tol et al. 2003).

Therefore, it is desirable for intervening strategies to rather respect existing social dynamics than to work against them. Existing interests in improving living conditions could be enhanced to help people migrate and become educated in an integrative way. Travelling family members could be educated and helped to regularly return home to improve adaptive knowledge and the use of early warning systems, situational documentation and aggregate local knowledge. And if collectives such as populations from Pacific Islands migrate together, knowledge about their hierarchies, traditions, and spiritual celebrations may help to find or create integrative solutions for them (as e.g. Pacific Islands, Böge 2008: 12).

The implementation of strategies is more promising when local agents are included instead of being excluded. So intervention strategies should be directed towards e.g. the destination regions of migrants, towards the enhancement of the variety or spread of best practice using modern scientific knowledge and best technology, or towards avoiding structural blockades. Thus, local and regional social dynamics that result from path dependency could be considered adequately and used to better mitigate and adapt to climate change. Nonetheless, concepts of centralized global climate institutions should be handled with care because an increasing institutionalization at the global level affecting all agents around the world can intensify their local conflicts.

Conclusion

The WBGU (2007) identified four major conflict constellations: climate change-induced degradation of freshwater resources, climate change-induced decline in food production, climate change-induced increase in storm and flood disasters, and environmentally induced migration, all of which are likely to cause conflict. But in addition to conflicts as reactions of people who are directly affected by changes in environmental conditions, also another level of potential conflict intensified by climate change, or rather policies addressing the causes and consequences, needs to be considered. Conflict may result as side effect of debating, communicating, and implementing particularly policies aimed at the prevention, mitigation of and adaptation to climate change.

This chapter argues that global climate policy, which selects one particular strategy among many to address climate change, can lead to an intensification of national and local conflicts around the world. The argument is based on the assumption that path dependency is shaping human behaviour. Using an expanded multi-agent model it is demonstrated that, via path-dependency effects, decisions at the global level can result in a reduction of the variety of locally applied action. Furthermore, this diminishing perception of options can coincide with an increasing radicalisation of positions and a reinforced strengthening of existing social hierarchies. If disturbed through climate change-induced disasters or revolutions, path dependent structures are likely to re-evolve in an even more intense way, which means that the involved people tend to act even more in ways that are best explained by path dependency.

This chapter focuses on expanding existing path dependency theory to include micro level effects, outlining a theoretical model and giving a few supporting examples. More empirical work is needed to confirm this analysis by investigating whether individual agents decide and act as predicted by path dependency theory with regard to the topics addressed in this chapter. If more empirical information on the importance of path dependency was available, this theoretical approach could be used to estimate local side effects of global climate-related policy, such as the exacerbation of international, national and local conflict. Furthermore, models that include path dependent behaviour may help to optimize intervention strategies by considering the inception of self-reinforcing processes and thus the direction of leverage effects on particularly generated peaceful dynamics aiming at mitigation of or adaptation to climate change.

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