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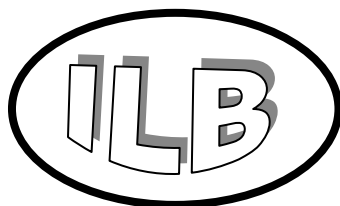
System Dynamics and Innovation in Food Networks 2012

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Lifting the Veil of Social Unrest about Food The Dynamics behind Transitions in Food Chains

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Abstract

This paper presents a novel approach to gain a deeper understanding of the forces driving sustainability transitions in food production and consumption. It follows a complex adaptive systems approach to study processes leading to sociotechnical innovations on a timescale of typically a decade. Dramaturgical analysis and agent-based simulation are combined to analyse how systems of institutional arrangements and production technology adapt to changes in public opinion and disrupting events like the outbreak of animal diseases or public health hazards. A dramaturgical analysis on the basis of newspaper articles and parliamentary records is performed for two cases. The resulting patterns of behaviour of key actors in these processes are modelled in an agent-based simulation. The purpose of the agent-based simulation is to validate that the assumed behaviours lead to the observed innovations, and to study how the system could have developed under different behaviours or a different course of external events.

Keywords: *Food chain, transition, discourse analysis, speech acts, opinion dynamics, agent based modelling*

1 Introduction

Hitherto the understanding of sustainability transitions in food production and consumption tends to be limited to a macro level identification and characterisation of a handful of phases or stages in food innovation processes. A deeper understanding of the dynamics behind these transitions, and in particular of the movement from one stage to the next, requires a micro level analysis of who voices what, when and how in the public debate about a specific food innovation. We conducted such micro level analyses in a comparative study of two Dutch public debates about pesticide residues on fruits and vegetables and animal welfare standards in livestock production. For these analyses we triangulated methodologies of discourse analysis and agent based modelling.

The discourse analyses of the two public debates were based on 150 documents (articles in national newspapers and professional journals and questions in Parliament) in the period 1995-2010. A dramaturgical approach was used to identify events, conditions and actors with a critical role in turning points in the debates. Furthermore, we conducted content-based media analyses by tagging newspaper articles with discrete speech acts of specified actors groups at specific moments.

The insights from the dramaturgical analyses were implemented in an agent-based model. This model was fed with tagged speech acts of non-governmental organisations (animal welfare, environmental, consumer and primary producer organisations) and food chain partners (retail companies, food processing companies). These speech acts were modelled to identify generic patterns in their effects on public opinion, intentions of NGO representatives and food chain partners, and adoption of innovations by primary producers. Section 2 presents transition theory as the conceptual background for the dramaturgical and contents analyses of two public debates in section 3 and agent-based modelling of these analyses in section 4. The fifth and final section of the paper discusses some salient aspects

of using agent-based simulations in understanding sustainability transitions in food production and consumption.

2 Transition theory – Conceptual background

Transition theory focuses on long-term societal developments of structural change, typically covering a time span of several decades. Analyses of the dynamics of societal developments over such a long time frame – the multi-level perspective (MLP) in particular (Rip and Kemp, 1998; Geels, 2002; 2005) – tend to focus on sociotechnical regimes, consisting of patterns of artefacts, institutions, knowledge, markets, supply networks, consumer practices, infrastructural rules and norms, assembled and maintained to perform economic and social activities (Berkhout et al., 2004).

This highly aggregated and abstract level of studying societal development patterns – resulting from multi-level interactions between landscape, regime and niche levels (Geels and Schot, 2007) – can be adequate to come to grips with systemic change processes and dynamics that cover 50 years or more but falls short in observing, understanding and explaining the behaviour of societal actors over a far shorter time span, e.g. between five and ten years. For this kind of analysis, a more in-depth view on human agency at the micro level of identifiable human actors and their interactions seems imperative.

The human agency dimension is present in transition literature, yet has remained remarkably underexposed. The MLP, for instance, has been criticised for underplaying the role of agency (Smith et al., 2005) and for lack of attention to such concepts as power and power exercise, politics and governance (Genus and Coles, 2008; Avelino and Rotmans, 2009). Although processes of multi-level alignment and change trajectories are assumed to be enacted by social groups – and thus to be both the medium and outcome of human endeavour (Giddens, 1984; Garud and Karnøe, 2001) – the making of independent choices by actors (Grin et al., 2011), interpersonal interaction patterns, power struggles and cultural-discursive activities (Geels, 2011) are not taken into account or are less developed.

Only recently, concepts like power, power exercise (Avelino and Rotmans, 2009), enactment of power through bargaining, threats and deal-making (Grin et al., 2010) and interests (Meadowcroft, 2011) are explored and incorporated in transition theory, as well as insights from perspectives such as discourse theory, cultural sociology and social movement theory (Geels and Verhees, 2011; Elzen et al., 2011). The reflexive governance approach to transition (Voß et al., 2009; Grin, 2010; Voß and Bornemann, 2011) sheds some light on the situation that there are multiple, heterogeneous and strategic agents (actors) seeking to exert influence on the pace and direction of transition processes. However, these attempts tend to reside at the macro level of aggregation and need further elaboration (van den Bergh et al., 2011).

Societal change dynamics are also studied in terms of triangular relations between state (government), market (companies) and civil society (non-governmental organisations). Business and society (Wartick and Wood, 1999) and societal interface approaches (Van Tulder and Van der Zwart, 2006) focus explicitly on rivalry and bargaining among and between institutions, organisations and individuals, by taking complexity, interaction dynamics, the balancing of shifting societal spheres, roles, responsibilities, interests, and ways of exercising power as conceptual points of departure. In these approaches, societal controversies (Hisschemöller and Hoppe, 1995) or issues (Jones and Chase, 1979; Bigelow et al., 1993; Schoonman, 1995; Lamertz et al., 2003) are at the heart of societal change dynamics. Differences in perspective on problem type, problem structuration and ways of

solving problems give rise to tensions and unrest between societal actors, resulting in processes of alignment and disalignment between competing frames (Miller, 2000). In this context, Wartick and Mahon (1994) distinguish between factual gaps, conformance gaps and ideals gaps.

The pace and societal impact of an issue tends to develop over time in a non-linear way, depicted as S-shaped curve, from shifting expectations to growing discontent and eventually settlement. Triggering events (e.g. media attention, call for a boycott, documentaries, lawsuits) and ways of framing the matter (Schön and Rein, 1994; Hajer, 1995) can be powerful mechanisms in influencing the perceived level of risk and urgency, the level of participation, the range of policy options considered and the nature of the political debate (Miller et al., 1997), and thus in nourishing competing public discourses on how issues should be managed. Also, attributes of actors or stakeholders involved, e.g. power, legitimacy, urgency (Mitchell et al., 1997), and perceived credibility have their effects.

The phases of the so-called issue life cycle provides a framework to observe and analyse when and how different societal actors become involved in the struggle for public credibility and adherence. To observe the politics of public deliberation, competing frames and rival acts of winning the hearts and minds of the relevant majority, Hajer (2005) approaches these societal power struggles as sequences of staged performances of conflict and conflict resolution. By adding elements of dramaturgy (e.g., scripting, staging, setting, performing) to the discourse analytical approach to policy processes, he attempts to infer under what conditions a variety of actors and voices emerge in the controversy, how the variety of contributions can be related to another, and under what conditions such statements can be made with influence on actual decision making.

In the next section this dramaturgical approach is used for analyses of the two public debates. Through identifying events, conditions and actors with a critical role in turning points in these debates and tagging newspaper articles with discrete speech acts of specified actors groups at specific moments, this dramaturgical approach is a first step towards a deeper understanding of the dynamics behind sustainability transitions in food production and consumption.

3 Two public debates – Dramaturgical and contents analysis

Dutch public debates on residues of pesticides in vegetables and fruits (Buurma, 2011a; Buurma, 2011b) and animal welfare in livestock production (Buurma; 2010) entailed long-lasting controversies between the involved societal actors but resulted in new husbandry systems and market segments. In retrospect, these public debates were constructive processes.

In the years 1998-2005 a public debate on compliance with maximum residue levels (MRLs) was staged by NGOs in the Netherlands. In the years 1998-1999 they called upon the government to immediately ban several pesticides because of the possibility of hormone disruption. The requests were rejected by the government for lack of scientific evidence. In the years 2000-2004 the NGOs took samples of vegetables and fruits in supermarkets, had them analysed on residues by a well-known laboratory, found unauthorized pesticides and exceedings of MRLs, and took two supermarket companies to court. The two supermarkets reached an agreement with the NGOs on MRL compliance. They took over the inspection on MRLs from the government and forced traders and growers to implement GlobalGAP.

In the years 2001-2007 a public debate on animal welfare in livestock production was staged by the Animal Protection Society. In the years 2001-2002 they called upon the government

to support the marketing of organic meat and to introduce regulations for animal welfare. In the years 2002-2004 they started consumer campaigns in newspapers, supermarkets and fastfood restaurants. In the years 2005-2007 the Animal Protection Society started an initiative for an intermediate segment between the conventional and organic segments in the meat market. They introduced the 'Better Life' label for animal-friendly meat. This initiative got support of specific feed suppliers, farmer groups, slaughterhouses and retailers. In 2011 the first supermarket stopped selling conventional meat and restricted themselves to selling animal-friendly meat.

These two public debates show a pattern of NGOs staging discussions and starting campaigns, which after some years results in new arrangements, codes of conduct and practices. This pattern is shown in Figure 3.1.

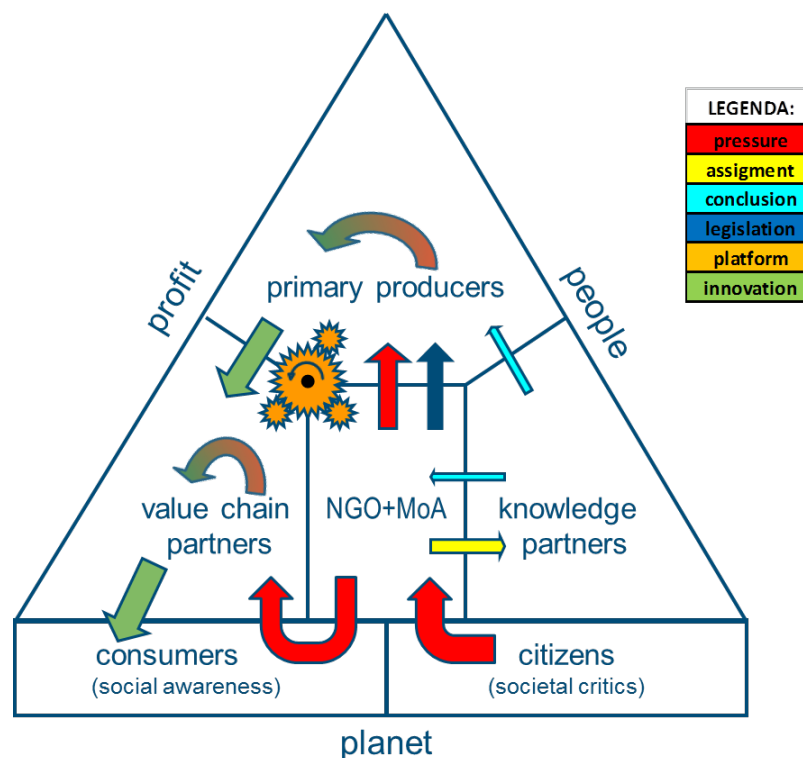


Figure 3.1. The dynamics behind transitions in food chains

The process starts with societal criticism on product qualities or production practices. The flow of criticism enters the central cell of the triangle. In this central cell the NGOs and the Ministry of Agriculture are active. They invite knowledge partners to objectify the societal criticism in measurable units. Subsequently, the societal criticism is translated into improved production systems, new regulations or societal pressure on primary producers. Another part of the societal pressure goes via consumers to value chain partners. The increased pressure in central, top and lefthand cell in the triangle frequently results in organising a platform, where involved actors align efforts for product or production innovation. As a result the flow of societal criticism is transformed in social awareness among consumers and a flow of improved products to consumer markets.

Figure 3.1 was developed on the basis of contents analyses of newspaper articles and Parliamentary questions. Contents analysis is a method to study the contents of communication. Babbie (2007) defines it as *“the study of recorded human communications, such as books, websites, paintings and laws”*. In the cases of pesticide residues and animal

welfare the recorded human communications were newspaper articles and Parliamentary questions. Lasswell (1948) formulated the core questions of contents analysis as: “*Who says what, to whom, why, to what extent and with what effect?*” These questions represent the aim of the analyses of the public debates. Reconstruction of the course of a public debate requires hundreds of documents over a period of several years. For the two cases newspaper articles and Parliamentary questions were retrieved from the databases www.lexisnexis.academic.nl and www.overheid.nl. In the case of pesticide residues the search words ‘bestrijdingsmiddelen’ (pesticides) and ‘gewasbescherming’ (crop protection) were used for the years 1995-2008. In the case of animal welfare the search word ‘Dierenbescherming’ (Animal Protection Society) was used for the years 1999-2010. It requires a systematic approach to analyse hundreds of documents and to reveal the events and mechanisms in the public debates that influenced the transition. Hajer (2005) introduced the dramaturgical approach as a systematic framework to analyse such processes. The dramaturgical approach considers the public debate as a theatre performance with scripting (story lines and actors), setting (locations and discourses), staging (parties involved) and plots (crucial moments). The public debates were summarised according to the format in Table 3.1. The table displays some of the records on pesticide residues.

Table 3.1.
Dramaturgic analysis of the public debate on pesticide residues (1995-2002)

Year	Actor/Stakeholder	Action/Campaign	Subject/Strategy	Answers/Reactions
1995	left wing MPs	questions to Minister of Public Health	effects of pesticides on public health; brain tumors, cancer, reproduction	no causal relationships and/or scientific evidence
1996	general newspaper	article on scientific report	oestrogenic effects of combinations of pesticides	important to investigate cumulative effects
1997	general newspaper	article on scientific report	recall of scientific report on oestrogenic effects	unravel mechanism of oestrogenic effects in mammals
1998	consortium of NGOs	campaign on pesticide residues in lettuce	postcards and posters: head of lettuce = condom ; hormone disruption; request to government to immediately ban seven pesticides frequently used in lettuce, strawberries and paprika	no scientific evidence ; NGOs are spreading panic under the general public
1999	consortium of NGOs	request to Minister of Agriculture	immediate ban on vinchlozolin and carbendazim; hormone disruption	
2000	consortium of NGOs	campaign on pesticide residues in strawberries	100 boxes of strawberries bought from supermarkets; analysed on residues by well-known laboratory; unauthorized pesticides and exceedings of MRLs; complaint against supermarkets with public prosecutor in Amsterdam	supermarkets hold strawberry growers responsible ; growers refer to pesticide authorisations in Belgium
2000	consortium of NGOs	request to Minister of Public Health	immediately stop the sale of vegetables and fruits with MRL exceedings; each day 50.000 Dutch children get too much pesticides; leading to behavioral disturbances	no scientific evidence ; further research necessary; conclusions of NGOs disputable
2001	left wing MPs	question to Minister of Public Health	exceedings of MRL in vegetables and fruit; risks for public health ; measures against MRL exceedings?	MRL is check on Good Agricultural Practice; levels much lower than for Acceptable Daily Intakes ; Food Inspection Authority monitors compliance with MRLs
2002	consortium of NGOs	campaign on pesticide residues in grapes from Greece and Italy	samples of grapes from supermarkets; analysed by well-known laboratory; two supermarket companies taken to court because of exceedings of MRLs; penalty of €20.000,- per violation ;	agreement with two supermarket companies ; no selling of grapes with residues anymore; check by independent laboratory; NGOs may publish the results

Table 3.1 illustrates that the public debate on pesticide residues created institutional changes after seven years of campaigning and staging discussion (orange window in 2002). The NGOs were not successful in convincing the Minister of Public Health and the Minister of Agriculture of the dangers of pesticides and pesticide residues. The Ministers continuously

mentioned that scientific evidence was lacking. For that reason the NGOs directed their campaigns at the supermarkets. The supermarkets were afraid of losing consumer confidence, and made an agreement with the NGOs on compliance with maximum residue limits. Together with the succession of involved social actors, the discourse (choise of words) in the public debate changes. Public actors use other concepts than private actors, farmers and growers use other concepts than traders and retailers. The discourses of the various actors depend on their profession and matching interests. Figure 3.2 shows the concepts applied in the public debates on pesticide residues and animal welfare.

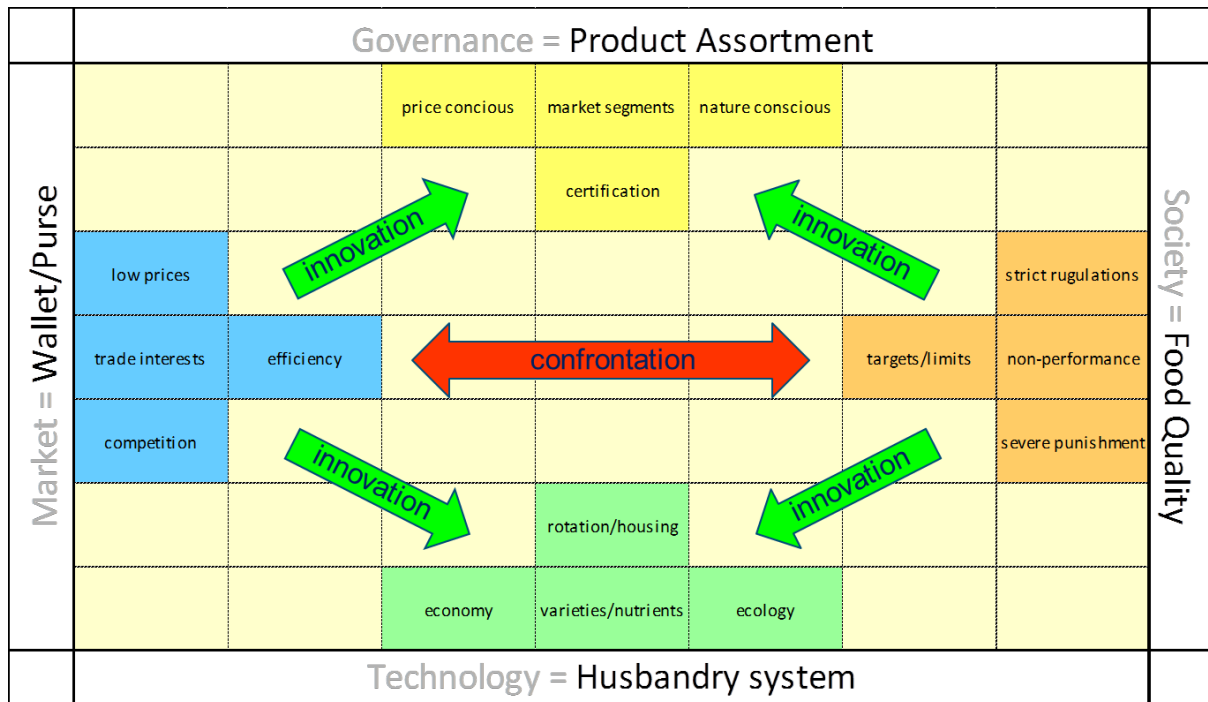


Figure 3.2. Concepts used in the public debates on pesticide residues and animal welfare

The public debate starts at the righthand side of the playing field with public sector concepts like strict regulations, targets/limits, non-performance and severe punishment. These concepts then alarm the private sector actors at the lefthand side of the playing field. They defend themselves with concepts like efficiency, low prices, trade interests and competition. These opposite sets of concepts represent a confrontation between public and private actors. When the debate develops, moderate-minded actors start to find technological or institutional options to resolve the confrontation between the opposing actors. On the technological level new husbandry systems are developed, starting from technological concepts like rotation, varieties, housing, nutrients, ecological and economic conditions. On the institutional level new products are developed, starting from concepts like market segments, certification, price and nature conscious consumers. One could say that the confrontation generates the urgency for innovation.

To ground the agent-based model 100 speech acts on animal welfare were selected from the newspaper articles and classified. Tables 3.2 and 3.3 show the results of this exercise. The debate started with appeals and warnings, followed by shaming the livestock and meat industry with emotional stories on animal abuse in production and transport. Simultaneously, vision-making and coalition-building took place. On the other hand, rejections and objections were launched. After some five to six years the climate changed and the debate focused on solutions and concerns about their feasibility.

Table 3.3 indicates that the Animal Protection Society (DB) dominated the debate. The contrasting profiles between strategist and campaigner indicate that the DB followed a two-track policy. On the one hand, they voiced warnings and complaints. On the other hand, they focused on vision-making and coalition-building. The retailers remained rather silent with just four speech acts by the end of the debate. The low cost farmers behaved as the victims, voicing rejections, solutions and concerns. The feed and meat industry brought forward several appeals and solutions. The progressive farmers adopted a constructive position in producing visions and solutions and in laying down their conditions.

Table 3.2.
Numbers of speech acts on animal welfare classified to types and years

Type of act	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total
Appeal		3	3	2		1					9
Warning	3	2	1	2	1				1		10
Shaming	4	2	2	4	5	2	1				20
Vision	3	3		4		2	3		1		16
Support	3			3	1		1	1			9
Rejection	2					3					5
Objection	1	1	1	4	1					1	9
Concern						3		2	1		6
Solution							3	5	1	7	16
Total	16	11	7	19	8	11	8	8	4	8	100

Table 3.3.
Numbers of speech acts on animal welfare classified to types and actors

Actor/agent	Consumer - low budget	Farmer - low costs	NGO - strategist	Feed/meat industry	Farmer - progressive	Retailer - strategist	Retailer - spokesman	NGO - campaigner	Consumer - responsive	Consumer - activist	Total
Type of act ↓	VICTIMS	SAVIOURS				PROSECUTORS					Total
Appeal		4	3	1			1				9
Warning	1	2	1	1			4		1		10
Shaming	2	1					16		1		20
Vision		9	1	3				2	1		16
Support		5	1	2				1			9
Rejection	2	2							1		5
Objection	2		1	4		1	1				9
Concern	5					1					6
Solution		5	6	3	1	1					16
Total	12	28	13	14	1	3	22	4	3		100

The dramaturgical approach revealed patterns in the dynamics of the public debates on pesticide residues and animal welfare. The challenge for Section 4 is to translate these dynamics in an agent-based model as a next step in developing a deeper understanding of the dynamics behind sustainability transitions in food production and consumption.

4 Complex adaptive systems – An agent-based model

Multi-agent systems offer a natural paradigm to simulate social processes. In such systems artificial software agents represent individual actors that can observe their environment, reason, decide and act upon it, and communicate with other agents. The agents can be modelled as actors, who have cognitive capabilities and decide on the basis of goals, beliefs, opinions and preferences. Agent based modelling can be used to simulate the behaviour of social systems in which many players interact. Strengths of agent-based models are that they allow for a broad diversity of actors to be simulated in a single system and that no a-priori assumptions about relations between behaviour of actors have to be made.

A well-established application of agent-based modelling is the simulation of opinion dynamics. Deffuant et al. (2000) propose an agent-based simulation model of opinion dynamics in which opinions are represented by a continuous variable x on the interval $[0, 1]$. In that simulation agents meet at random and, during the meetings, exchange opinions if their difference in opinion is less than some threshold d . If an agent having opinion x meets an agent with opinion x' at time t , opinion x is updated as follows:

$$x(t) = \begin{cases} x(t-1) + \mu(x'(t-1) - x(t-1)) & \text{if } |x - x'| < d \\ x(t-1) & \text{if } |x - x'| \geq d \end{cases} \quad (1)$$

where μ is a convergence parameter, $0 \leq \mu \leq 0.5$. One can think of d as the agent's openness to others' opinions or uncertainty about its own opinion, and of μ as the agent's flexibility or urge to compromise in a discussion. Deffuant et al. (2000) elaborate on two generalizations of this model: they introduce social networks as structures that restrict the agents' encounters, and they generalize the scalar representation of opinions to a vector representation of opinions on a set of issues. For all of these models, they show by means of multi-agent simulations that for any initial distribution, opinions converge to one or more clusters. The maximum number of clusters depends on the value of d .

Hegselmann and Krause (2002) present a variety of opinion dynamics models. They interpret the model of Deffuant et al. (2000) as a model of bounded confidence and refer to d as the 'confidence level'. Hegselmann and Krause (2002) produce an analytical proof for the convergence found by Deffuant et al. (2000) in multi-agent simulations. Furthermore, they introduce asymmetric confidence:

$$x(t) = \begin{cases} x(t-1) + \mu(x'(t-1) - x(t-1)) & \text{if } -d_l < x - x' < d_r \\ x(t-1) & \text{if } x - x' \leq -d_l \text{ or } x - x' \geq d_r \end{cases} \quad (2)$$

with $0 \leq d_l, d_r \leq 1$. Also in the case of asymmetric confidence, where $d_l \neq d_r$, opinions are found to converge to one or more clusters. A special type of asymmetry is opinion dependent asymmetry, where $d_l > d_r$ if $x < 0.5$ and $d_l < d_r$ if $x > 0.5$. In that case, Hegselmann and Krause (2002) find polarization of opinions: convergence in two clusters at the extremes.

These results are encouraging to apply the concepts of opinion dynamics for modelling a sociotechnical innovation process. The formulation of an agent-based model of opinion dynamics requires the definition of a population of agents and their capabilities, an interaction structure or network with data about the probability or frequency of interactions of particular agents, and parameter values for the models of the agents' capabilities. As a first step to model the process of sociotechnical innovations driven by social unrest, a prototype of an agent-based model has been developed in NetLogo (Wilenski 1999). The present agent-based model implements opinion dynamics according to equation (1). Agents

have a continuous opinion x ranging from 0 (e.g., “production and distribution of meat and eggs should aim at cost minimization”) to 1 (e.g., “production and distribution of meat and eggs should aim at animal welfare maximization”). Three classes of actors are discerned:

- The public (citizens / consumers);
- Intermediate actors (supply chain partners and public organisations);
- Primary producers (farmers).

Each of the classes is divided into subclasses according to published sources about categories in Dutch society. The citizens/consumers are classified according to Helsing-Couvret and Reuling (2002), supply chain partners according to Van Tulder et al. (2009) and primary producers according to De Lauwere et al. (2002). An agent is randomly assigned to one of the subclasses of its actor class based on the frequency distribution of the subclasses. Parameter values for each of the subclasses are assumed by expert judgement.

The model starts with an opinion value of zero for every agent, except for some intermediate actors, e.g. representatives of the Animal Protection Society. The latter are modelled to have a profound opinion at the other extreme and do not change their position. However, they are calling in the desert, given that the opinions of the others equal 0 and values of d are less than 1. This may be changed by the occurrence of events that get media attention with emotional impact, e.g. television images of animals being put down and of dead animals being loaded into trucks for destruction at the outbreak of a disease. During the simulation period, such events can occur with some frequency. Events are modelled to temporarily increase the susceptibility of citizens/consumers for other opinions, i.e. to increase the value of d . The value of d subsequently decays to its original value but before that is realized the opinions of some agents may have shifted and they may have formed clusters that can survive and attract other agents, until the next event stirs up opinions.

For a shift in the public opinion to occur, two conditions must be satisfied according to this model: the campaigners of the NGOs (e.g. the Animal Protection Society) must sufficiently raise their voices, and events must occur that increase the susceptibility of part of the public. The probability of a reaction and the impact on the opinion depends on the consumer segment. More consumers are likely to react according to the emotional impact of the event. When sufficient consumers have adopted the issue, the supply chain partners are triggered to follow. Intermediate actors regularly meet, and as a result their opinions can converge to clusters according to opinion dynamics. When sufficient intermediate actors have crossed some opinion threshold, they exert pressure on the farmers to adapt their farming practices. The pressure from supply chain partners will convince some farmers to adapt their production systems. When sufficient farmers have adapted, their produce can be made available on the consumer market and the consumers with a strong opinion in favour of the social responsibility issue will be willing to buy the product. Like consumers, farmers are modelled to exchange opinions. When the pressure from supply chain partners grows and more farmers adapt, other farmers’ willingness to adapt will also grow. Products appear more and more in the supermarkets and more consumers can buy the product.

Figure 4.1 displays a screen shot of a situation that has developed under pressure of NGO campaigners and media events. The supply chain partners have adopted the opinion that the social responsibility norm is a value adding product attribute to be offered to the consumers, while sufficient farmers are willing to supply their produce according to this norm. In such a situation, producers, supply chain partners and NGOs can settle for an agreement that guarantees a product offer complying with social responsibility norms.

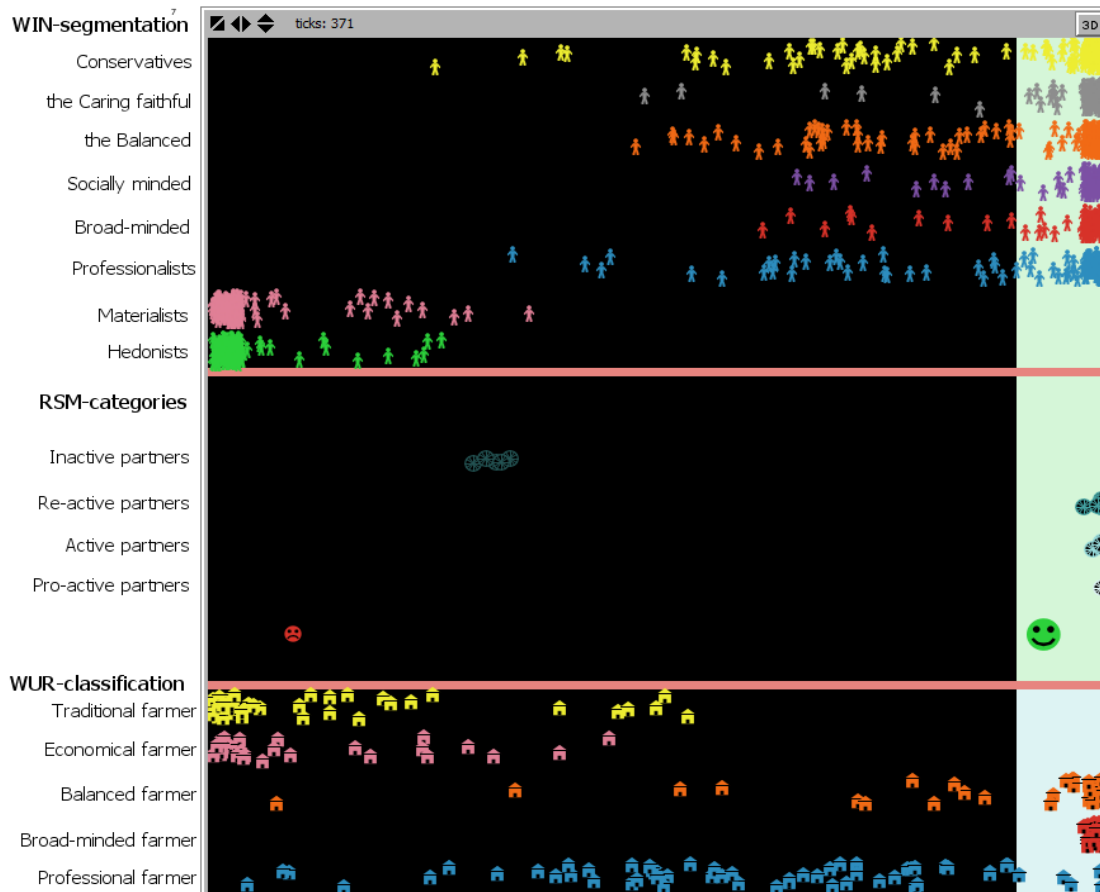


Figure 4.1. Screen shot of a situation where the conditions for a sociotechnical innovation are satisfied (left hand position is cost minimization oriented; right hand position is social responsibility oriented)

5 Discussion

Results obtained with the prototype of the agent-based model indicate that processes leading to sociotechnical innovations can realistically be simulated with such a model. One may not expect a model like this to predict the outcome of future innovation processes but from analysing historical cases useful insights can be gained to guide future processes. Thus, in addition to its role in advancing the scientific understanding of sociotechnical innovation processes, the model can be a valuable tool for policy makers involved in such processes. However, it should be noted that the model must be further developed, for instance introducing asymmetric uncertainty as in equation (2), before it can be calibrated against actual data and before meaningful sensitivity analyses can be performed. The concept of opinion dynamics may be suitable to simulate the behaviour of consumers and producers but it is less feasible to model the intermediary actors, where speech acts and positions of individual actors may have their influence on the course of the process. Cognitive modelling of those actors and the effects of their speech acts is required in order to analyse the history of actual cases and to answer questions like “*what if actor x would have...*” and “*what if event y would not have occurred...*”.

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