Exploring policy interventions for rural sustainable development

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Abstract. Rural development policy and the new Common Agricultural Policy (CAP) increasingly place agriculture in a wider multifunctional context taking into account their role in the rural economy, the quality of the environment and food safety. This expanded perspective requires an understanding of agricultural activities beyond farming, including food and energy processing, transport, retail and other land use related activities like tourism. Simultaneously, it requires a more systematic analysis of the heterogeneity of actors and diversity of physical, socio-cultural and institutional environments within and between different European rural regions. From a methodological perspective, the increased scope poses additional challenges with regard to the inherent uncertainty associated with the modelling results and their application to the evaluation and development of policy interventions. This paper presents a new methodology, based on agent-based modelling, that explicitly focuses on the role of uncertainty in the behaviour of different supply chain actors and its consequences for rural sustainable development. The aim of the methodology is to contribute to the analysis, evaluation and development of robust policy instruments that improve and stimulate rural sustainable development over a range of potential future scenarios. The methodology is developed to assist DG Agriculture in implementing the newly orientated CAP, Rural Development Policy and the Lisbon Strategy over a period of 15 years[1]

Keywords: rural development, agent-based modeling, scenario analysis, supply chains, diversity

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1 Analysing rural sustainable development

Agriculture and forestry have and still play a central and vital role in many regions throughout Europe. A strong and competitive agriculture and forestry is important for the economic development of regions, for creating a living countryside and improved quality of life and they are required for maintaining and preserving Europe's unique rural heritage. The new Common Agricultural Policy (CAP) recognises the expanded role of agriculture and attempts to support its multi-functionality by increasing the scope of its measures to support diversification, the maintenance and improvement of the rural environment and the role of agriculture in social and economic welfare. This expanded view of the role of the agricultural supply chain within rural sustainable development means that policy interventions have to support several and often conflicting objectives simultaneously and that both farmers and other supply chain actors have to be considered. It also requires consideration of the diversity of activities and interrelationships between farmers and other supply chain actors in different regions throughout Europe, because different contextual settings can lead to different responses to the same policy interventions. An analysis of policy interventions has to identify these interrelationships and analyse the impacts of interrelationships on the effectiveness of policies for rural development.

The analysis of interrelationships between agricultural supply chains, rural development and long-term policy interventions poses some methodological challenges. First of all, there is a large heterogeneity between actors operating in and governing the region, both in terms of their physical properties and their individual and collective socio-economic objectives driving their behaviours and responses towards new policy interventions. This diversity of behaviours is the driving force for the network evolution, with each actor attempting to pursue its individual objectives within a constantly changing external environment. Secondly, the properties and patterns of rural development are a function of the relationships and interactions between these interdependent actors, their perspectives and responses to each other and the complex interactions between the system level properties and the farmers' and organisations' individual objectives. Finally, their behaviours and system performance depends on some unknown externalities affecting these regions as a whole. Each of these processes does not only change the course of the individual actor within the network, but also affect the evolution of the rural network as a whole. Figure 1 schematically represents the interaction between actors' behaviour and the performance of the region as a whole.

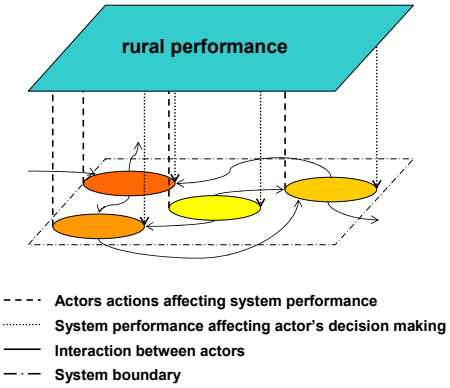

Fig. 1. *The interrelationship between actors in the agricultural supply chain and rural development*

Agent-based modelling (ABM) is well equipped to address the methodological challenges eminent to any complex adaptive system. ABM is based on modelling the heterogeneity between the different actors within a rural region. It explicitly explores the co-evolutionary process between the adaptive features of actors and their consequences for agricultural supply chain structures and their associated impact on rural development. Furthermore, it allows for exploring the self-organisational features of rural regions by capturing the role of social institutions of norms, values and regulatory frameworks in providing stability and social cohesion in the region. All in all, ABM provides a method that both recognises and improves the understanding of the complex processes by which an emergent property like rural sustainable development is established.

Although ABM can provide increased insights and understanding, it cannot accurately predict the consequences of policy interventions for rural sustainable development. Since regions are open systems, their evolution will always be affected by some uncertain or unknown variables, either within or outside of the region, either now or in the future. This uncertainty challenges the application of modelling results and insights within the inherent normative and positive context of policy making, even if the research is carried out as objectively as possible (Brunner 1999:74). In other words, the challenge for using ABM in a policy context is to develop a methodology whereby the modelling results explicitly engage with the inherent uncertainty they represent. More pragmatically, such methodology has to address the question which characteristics, decision making processes and physical properties are required to be captured within an ABM to make the analysis useful for policy development. One the one hand, it is impossible to capture all the details of rural regions within a single ABM, while on the other hand these intrinsic details is exactly what distinguishes the operation and evolution of many rural regions within Europe. Similarly, such methodology should address the question how to analyse current and future uncertainties and their impact on the behaviour of supply chain actors now and in the future.

This paper proposes a methodology to address the inherent uncertainty associated with the development and use of ABM for analysing long-term policy interventions, especially within the context of diversity. Chapter 2 provides an overview of current ABMs used within the agricultural sector and regional development. The proposed methodology is described in chapter 3 and further developed in chapter 4, 5 and 6. Chapter 7 provides the conclusions.

2. Agent-based modelling and rural development

In the context of rural development, a large array ABMs have been developed for exploring the impacts of human behaviour on land use and the role of social institutions for behaviour change (Hare and Deadman 2004; Matthews, et al. 2007; Parker, et al. 2003). These ABMs have been applied to address different research questions ranging from the development and evaluation of policy instruments to the testing of social and economic science concepts (Matthews, et al. 2007:1449). Beside from the specifics of these applications, most ABMs have two aspects in common. On the one hand they consist of a number of actors that make decisions about land use, while their decisions are simultaneously influenced by the economic, social and/or environmental conditions in which they operate. Figure 2 shows the relationship between the choices made by the different actors and how the outcome of these choices (activities A_1,A_2 …A_n) affect the system performance in terms of economic, socio-cultural and environmental performance.

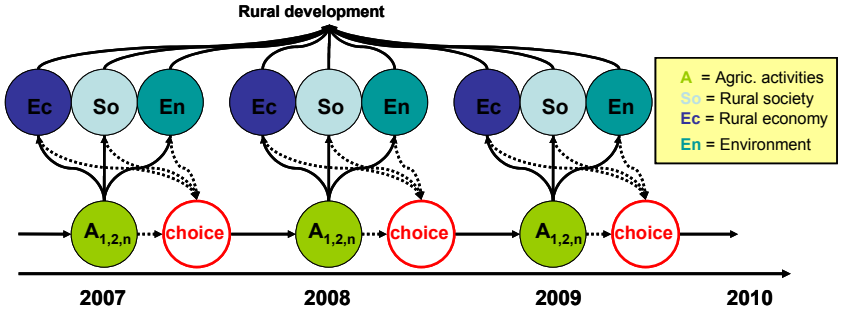

Fig. 2. *The structure of the agent-based modelling approach. Current agricultural activities and rural characteristics impact on the decision making process of the agents within the network, which subsequently affects the activities and regional characteristics at later stages in the region.*

Several ABM frameworks attempt to contribute to the development and evaluation of policy interventions in rural regions (Balmann, et al. 2002; Deffuant, et al. 2005; Weisbuch and Boudjema 1999). These ABM attempt to provide a methodology that allows policy makers to the consequences of different policy options for promoting rural sustainable development in EU regions. This means that the modelling results of the ABM has to provide policy makers with information and understanding about the

consequences of their interventions for a range of diverse regions within Europe and under a range of unknown future scenarios. In this context, the following five criteria can be identified for the development of an ABM.

1. The model needs to represent the different physical characteristics of the regions, the structure of the agricultural supply chains, and the socio-cultural and socio-institutional arrangements that determine the flow of capital and knowledge within these regions. In other words, the ABM should be empirically based reflect the characteristics of the region within which they operate and the regional characteristics should change according to the behaviour of the supply chain actors.
2. The model should provide insights in how the complex institutional and governance structures impact on different behavioural rules that actors might employ and how that impacts on the agricultural supply chain evolution within a particular region. It also requires consideration of how agricultural supply chain actors might respond to changes in the environment now and in the future. Furthermore, it requires consideration of the interdependency between agricultural activities within the region and other sectors impacting rural development.
3. The model requires a representation of different future scenarios on the European and world food- and/or energy markets and the consequences of such futures on the behaviour and development of the existing agricultural supply chains over the timeframe in which EU policies are developed (around 15 years).
4. The model has to be able to explore the consequences of EU policy interventions on the activities within the agricultural supply chains in different regions in the EU. This requires a set of performance criteria that not only evaluates the functional performance of the region, but also considers how different behaviours and/or interventions influence the structure of the agricultural supply chains.
5. The model should allow for exploring the inherent uncertainties associated with rural development and how uncertainty influences the evaluation of existing and the development of new policy instruments. In other words, the methodology should accommodate different view points and stakeholders and how different values associated with performance criteria might impact on the overall evaluation of policy instruments.

Existing ABM for land use modelling and policy development do not fulfil these criteria. Some ABM are based on household income maximisation algorithms representing farmer behaviour (AgriPolis and RegMAS) (Happe, et al. 2006; Lobianco 2008). Other models do represent social interaction, but are not empirically based (Cioffi-Revilla and Gotts 2003; Polhill, et al. 2007; Weisbuch and Boudjema 1999). Finally, there are several ABM that are empirically based and replace conventional income maximisation functions of farmers with a 'benefit target function' (Albisser and Lehmann 2007:8) or socio-psychological theories of strategic behaviour (Franks, et al. accepted). However, these models do not explicitly engage with future uncertainty and exclude the role of other supply chain actors and their responses to potential policy interventions.

The list of criteria is a major challenge for any ABM development and requires simplifications to reduce the complexity of the problem. First of all, it should be recognised that it is impossible to accurately represent how regions will develop over the next 15 years. The uncertainties associated with and the specific form of the behaviours of different agents in different regions is unknown, especially if one would like to consider current as well as future behaviour. Furthermore, there are so many external variables that affect the evolution of agricultural systems, including the development of new and currently unknown innovations or farm practices, that is not possible to predict the exact consequences of policy interventions. This suggests that the inherent uncertainty associated with the evaluation of policy instruments should be the focus of the ABM.

3. Methodology

The previous section outlined several challenges for the development of an ABM for evaluating EU policy interventions. This section will propose a novel methodology to use ABM for the analysis and evaluation of policy interventions on rural development. The methodology consists of three elements; 1) it is empirically based to provide a real-world context in which the policy interventions can be explored, 2) it uses scenario analysis to explore the inherent uncertainties associated with the future and 3) it evaluates policy interventions on the basis of their robustness over a range of scenarios.

First of all, the proposed methodology is empirically based and uses interviews with farmer representatives, supply chain actors and rural development experts to gather information about the current and potential future agricultural supply chains that are possible within a region. Information is gathered on the associated consequences of different activities that farmers and other supply chain actors can undertake over the course of the analysis. Both physical and institutional regional characteristics, such as soil quality, agricultural land availability, infrastructure and the number and role of local and national governance agencies are collected to understand the context in which the supply chain actors operate. The emphasis will be on the impact of agricultural supply chains on the region and actors operating in other sectors (ie tourism, service industry) will be represented as exogenous variables affecting the evolution of agricultural supply chains.

The second part of the methodology consists of evaluating the potential evolution of the agricultural supply chains on the basis of a set of ‘behavioural rule’ scenarios. These ‘behavioural rule’ scenarios represent different scenarios in which the farmers and other agricultural supply chain actors use different ‘mental models’ to inform their decision making. These mental models are construed from two set of rules. The first set of rules represents the actor’s interpretation of its environment and determines which different network characteristics are used in his/her decision. The second set of rules represents the cognitive rules of actors and describes how information is

processed into a decision. The 'behavioural rule' scenarios are constructed to evaluate a large range of alternative futures possible.

The final step is to evaluate the consequences of policy interventions on the evolution of the agricultural supply chains and their associated impacts for rural development. Policy interventions are explored over a range of regions within a particular external context to analyse how current regional characteristics might result in different responses. However, instead of using ABM results as predictive representations of the future development of regions, the results are used as distinct scenarios on how the region might evolve. Subsequently, policy interventions are assessed according to their robustness in stimulating rural development over a range of different potential futures.

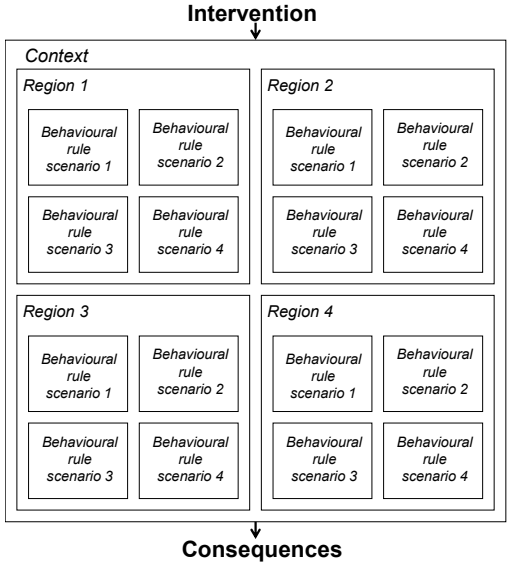

Fig. 3. *Methodology to explore the consequences of policy interventions on rural development*

Figure 3 schematically shows the methodology suggested within this paper. Four different sets of 'behavioural rules' and their consequent supply chain evolutions are applied to each region. This means that for each region four different evolutionary pathways of rural development are explored. Subsequently, the consequences of particular EU policy interventions are explored over the complete range of scenarios (for four regions this means a total of 16 evolutionary pathways). The final step is to compare the results of policy interventions with each other to determine their robustness in improving rural sustainable development (not shown in figure 3). The analysis of different policy interventions takes place within a particular context (ie increasing global food prices, future oil shocks or changes in consumer preferences) and can be repeated if policy makers want to consider additional context scenarios.

The next three sections discuss each of the suggested methodological stages and how they have been implemented into the analysis

4. Empirical ABM for rural development

Only in the last five years, there is an increase in ABM that are applied to empirical cases (Janssen and Ostrom 2006). According to Janssen and Ostrom (2006), the reason for the small number of empirical studies is the difficulty with subjectivity of information and the associated problems for verification and validation of the models. There are several other challenges associated with applying ABM to empirical case studies. For rural development, the development of an ABM requires information about how strategic behaviour of actors in the supply networks, both functional and institutional, determine current and future activities and their subsequent effects on rural economic development and the environment. It follows that information is required about what variables (both inside and outside the region) determines farmers' and other supply chain actors' behaviour within a particular region. An analytical framework developed in Kempener, Cohen et al. (2008), is used to assess what information is required to understand how farmers and other supply chain actors make their decisions. This framework is developed on the basis of a larger range of socio-psychological and socio-cultural theories describing particular decision making processes.

A distinction is made between different regional characteristics that impact the decision making process of farmers and other supply chain actors. Four different levels of characteristics are distinguished. Firstly, there are 'functional' characteristics that inform the behaviour of actors. These 'functional' characteristics are those characteristics that are formalised within the network and which have an economic value to an actor. Functional characteristics include the distribution of resources within the region, the price of resources, crops and technologies available and infrastructural features to name a few. The second category of network characteristics is named 'implicit' characteristics. These are characteristics that impact on the decision making process of actors, but which are not formally recognised or easily quantified. On an individual level, these implicit characteristics consist of individual norms, values and beliefs. On a relational level, they consist of trust and loyalty between existing players within the network. Finally, on an institutional level they consist of socially embedded norms and routines, particular beliefs and legitimacy within the region.

Together, these characteristics inform how actors in the regions make decisions about land use, purchase and sales of agricultural products, the investment in processing capacities and whether the products are sold within or outside the region. In other words, these different network characteristics inform the relationship between the different actors within the region and how the different resources within the region are used and contribute to rural development (see figure 4).

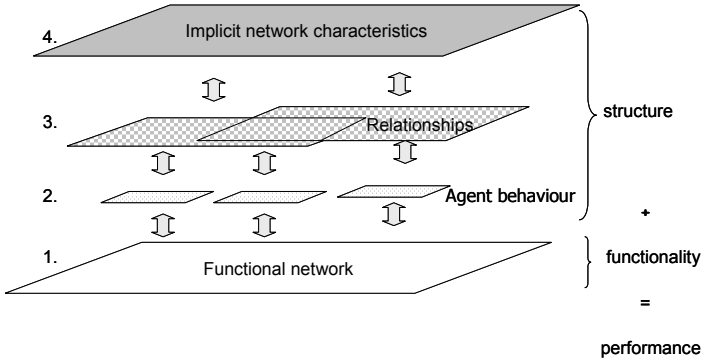

Fig. 4. *Four level analytical framework for the analysis of rural development (Kempener, et al. 2008)*

It is suggested here that an analysis of rural development should consider and identify the role of these different characteristics and their importance in the context of the regions. Furthermore, it is argued that information is required on how these different characteristics might change over time and how behaviour of actors might impact the functional and implicit characteristics of a region.

There is a high level of uncertainty associated with each of the parameters and how they inform and affect the behaviour of actors within a region. Furthermore, there might be a high diversity between the different actors in one particular region and how they perceive the importance and relevance of any of these characteristics on their behaviour. The consequences of this uncertainty on the analysis of rural development have to be accommodated for and explored within the modelling framework. The next step proposes an approach to systematically explore the role of uncertainty on the evolution of agricultural supply chains within a region.

5. Exploring different behavioural rules

The second step in the methodology is the development of a set of 'behavioural rules scenarios'. 'Behavioural rule scenarios' represent different mindsets that farmers and organisations operating within the region can adopt. Each mindset is represented by a different set of decision rules determining which network characteristics inform the actor's behaviour and how they use this information in their decision making. Since each set of behavioural rules represent a coherent view on how the future might unfold, they are consistent with analysing the future using multiple scenario development (Schoemaker 1993:197).

Traditionally, agricultural research has used an economic framework to analyse and understand the impacts of policy interventions on the development of regions. From this perspective, farmers often tend to be seen as businessmen responding to price and regulatory interventions from an economic rational perspective. Similarly,

the interaction between different sectors and regions is analysed from a market perspective in which buyers and suppliers are free to exchange goods and services most effectively. However, there are several caveats associated with this perspective (Shucksmith and Herrmann 2002:39). Firstly, there is no empirical evidence that farmers, or any organisation, behave economically rational (Conlisk 1996). Farmers and other supply chain actors have individual objectives that are socially constructed, they are limited in terms of information, use different mechanisms to come to decisions and are and cannot be aware of all decision alternatives available (Castello, et al. 1997:455; Lynne, et al. 1988:12). Secondly, the 'economic market' is a concept which does not exist in reality. In regions, the supply and demand of goods and services is socially constructed and governed by social relationships between the different actors and the institutional setting in which they operate (Bourdieu 2003). Furthermore, the notion of economic rationality has also been rejected on the basis of empirical observations of farmer diversity (Whatmore 1994:32). An agricultural economic perspective fails to explain why farmers in similar or in one and the same region have such a diverse set of agricultural practices.

Several alternative frameworks have been developed in an attempt to understand farmers' behaviour. Examples of these alternative frameworkd include Van der Ploeg's (1994) notion of farming styles, Bourdieu's concept of *habitus* (Bourdieu 2003), the farming subculture approach by Vanclay (Vanclay, et al. 1998) or the Agricultural Knowledge and Information System approach by Röling. Others have applied cognitive theories of farmer behaviour, such as the Theory of Reasoned Action (TRA) and the Theory of Planned Behaviour (TPB) on farming activities (Burton 2004; Burton and Wilson 2006; Lynne, et al. 1995; Lynne, et al. 1988). Although there have been discussions on the role of different conceptual frameworks of farming behaviour, there have not been any serious attempt to connect these frameworks[2]. Furthermore, the analysis of different farming behaviours is dominated by applications of cluster analysis attempting to correlate physical characteristics to farmer behaviour. For example, Mitchell discusses how social, cultural and personal characteristics and how learning processes and experiences influences farmer decisions, but the assessment of typologies is based on a set of physical characteristics (age, education, gender, soil quality, size, income, debt ratio and relative costs) (Mitchell 2006).

Similarly to research in agriculture, many different schools of strategic behaviour have been developed over the years each advocating a different framework to describe their strategic decision making processes. Although there has been research that attempted to relate strategic behaviour to physical characteristics of the firm (ie larger firms operate less risk averse, but are less flexible), the research has focused

2 For example, Vanclay, Mesiti et al. (1998:86) argue that their farming subculture approach is similar to van der Ploeg's farming styles, but that their approach also "has certain similarities with the notion of cultural habitus. Slee, Gibbon et al. (2006) attempt to connect habitus with farming styles by arguing that it is highly likely that different habituses are recursively connected to particular farming. Habitus provides the value system on which the socio-technical practises of a farming style are played out. However, they simultaneously recognise that although farmers might share common physical characteristics in terms of farm practices, they do not necessarily have to share similar habiti. Similarly, farmers with completely different farming practices might share the same knowledge and value base.

more on the processes that play a role in strategic decision making, how these processes manifest themselves and how they are related to particular characteristics within the decision making process and the structural environment in which the firm operates.

Mintzberg and Lampel (1999) identify two dimensions that characterise the different descriptions of strategic decision making processes. The first dimension is related to how an organisation interprets uncertainty in its environment (interpretation process), and the second dimension is related to how the organisation deals with this uncertainty in its decision making process (cognitive process) (Mintzberg and Lampel 1999). The continuum along each dimension is based on antagonistic views about how an organisation views the inherent uncertainty associated with its behaviour and how they attempt to reduce this uncertainty trough strategic decision making process. In terms of the interpretation process of the environment, some scholars suggest that it is purely' resource based involving network characteristics like input and output prices, technology specifications, regulation and infrastructure (Ansoff 1965). On the other end of the spectrum, the interpretation process can be viewed as 'institutional' affected by individual norms and values, symbolic meanings, relational characteristics like trust and loyalty and legislative, normative and cognitive rules (DiMaggio and Powell 1983; Giddens 1984; Podolny 1994). Similarly, the cognitive processes that convert this information into action can be differentiated. One the one hand, there is the "rational" approach assuming that information is used to maximise the organisation's subjective expected utility (SEU); while the 'intuitive' approach assumes that decisions are made 'on the fly' in the form of heuristics and routines and/or imitation processes (Gigerenzer and Goldstein 2000; Haunschild and Miner 1997; Nelson and Winter 1982).

In principle, each of the schools offers a different perception on how uncertainty affects the decision making process and how uncertainty can be reduced by either representing the world in a particular way or by structuring the decision making process in a particular fashion. As such, these schools of thought represent different 'mental models' for strategic decision making (Sterman 2000). This view of organisational behaviour governed by different mental models coincides with Simon's theory on human decision making and the role of mental models. According to Herbert Simon, this dual side of uncertainty, a cognitive side and an ecological side (Gigerenzer and Goldstein 2000:622), is reflected in the mental models that people and organisations use: "Human rational behaviour is shaped by a scissors whose two blades are the structure of task environments and the computational capabilities of the actor" (Simon 1990:7). Jager (2000), for example, applies these two dimensions of human behaviour to characterise different 'mental models' used by consumers and uses this meta-model for the development of an agent-based modelling framework (Jager 2000:79).

It is argued here that the same method used to differentiate the behaviour of firms can be applied to farm behaviour with each set of behavioural rules characterised by 1) a particular mental representation of the world and 2) a particular set of cognitive processes. The advantage of using 'mental models' rather than farm and firm

characteristics to determine behaviour is that an analysis of rural development is inherently dynamic, which means that farm characteristics will definitely change over time while 'mental models' might remain more static. Thus, although farm characteristics explain to a large extent different farmer practices and behaviour, it is the mental models that determine how these farms evolve over time. By using the 'mental models' as the basis for scenarios, it is possible to explore how farm characteristics might change over time and what effect this has on the evolution of the agricultural supply chains within a particular region. Such approach would resonate Bourdieu's observations that it is important to understand *how* farmers interpret their environment (the relationship between habitus and the field) and *how* they give meaning to capital (the symbolic capital) within their decision making process.

Instead of an attempt to empirically validate the exact form of the different 'mental models' of each actor in a region (a cumbersome process and unreliable if the analysis covers a longer period of time, because they can change), an alternative approach is to use different 'behavioural rule scenarios' to explore the range of possible behaviours and their associated impacts on rural development. A coherent set of scenarios can be developed for both farmers and firms on the basis of how they perceive uncertainty. As previously discussed, there are two processes that play a role in dealing with uncertainty. The interpretation process determines what information is used by the farmer and ranges from the use of functional individual characteristics alone to inform decisions to the use of implicit social network characteristics (ie cultural values). The cognitive process determines how information is translated into action ranging from full rationality (reasoning) to processes of habit/imitation and intuition (automated). Combining the two dimensions of mental models with an understanding of different processes to deal with uncertainty (as per Jager's (2000) mapping) provides a two-dimensional matrix within which different scenarios can be explored (figure 5).

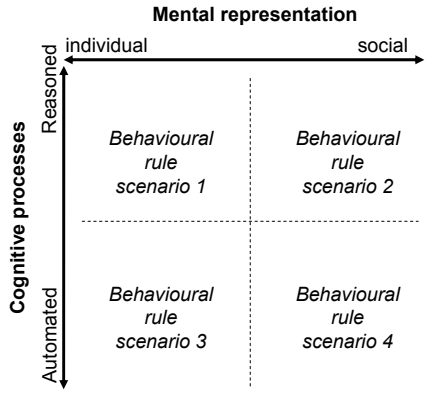

Fig. 5. *A set of scenarios to represent different mental models of farmers and other actors in regions*

Each 'behavioural rule scenario' is thus a set of 'cognitive processes' and 'mental representations' represented as a distinct different scenario (Jungermann and Thuring

1987:266). By exploring how the region develops if all farms and firms adopt a particular 'mental model' (as represented in each behavioural scenario), it is possible to explore the potential space over which the regions might evolve and the potential consequences of interventions to stimulate rural development (Kempener 2008). It is then possible to explore how robust particular policy interventions in promoting rural sustainable development over a set of different behaviours.

A further advantage of this approach is that it does justice to the empirical observations of farmer diversity. Although in each 'behavioural scenario' the farmers interpret their environment in the same way, it is eventually the combination of their interpretation and the context in which they operate that determines the farmer practices they adopt. Thus, although each farmer has the same mental model in a particular model run, their practices and experience is uniquely determined by the different contexts in which they operate. This applies to the farms as well as the firms and/or other actors operating within the region. The following set of processes is suggested to comprehend each 'behavioural scenario:

Table 1. Overview of different 'behavioural rule' scenarios to evaluate different evolutionary pathways for agricultural supply chains

	Farm	Firm
Scenario 1	The farm bases its evaluation of all alternatives available and it chooses the option that contributes most to a sustained household income	The firm bases its evaluation of all alternatives available and it chooses the option that maximises profits
Scenario 2	The farm only evaluates those options that are socially acceptable and it chooses the option that contributes most to a sustained household income	The firm only evaluates those options that are socially acceptable and it chooses the option that maximises profit
Scenario 3	The farm bases its evaluation of all alternatives available and chooses the option that is most closely aligned with his/her experience	The firm bases its evaluation of all alternatives available and chooses the option that is less risk averse
Scenario 4	The farm only evaluates those options that are socially acceptable and chooses the option that is most closely aligned with his/her experience	The firm only evaluates those options that are socially acceptable and chooses the option that is less risk averse

Additional scenarios can be used to explore in more detail alternative behaviours and their consequent impacts on rural development.

6. Evaluation of modelling results

The final step is the use of modelling results for evaluating existing and developing new interventions for stimulating rural sustainable development. The disadvantage of scenario analysis is that it provides a range of different narratives on how a region might evolve over the next 15 years, but there are limited attempts to formally evaluate these different evolutionary pathways.

Durbach and Stewart (2003) have suggested scenario-based goal programming (SBGP) as a means to evaluate different performance criteria over a range of evolutionary pathways in order to determine those interventions that are most robust in terms of their impacts. The use of SBGP is similar as the *regret method* suggested by Lempert, Groves et al. (2006:516) for evaluating the robustness of strategies, except that SBGP is grounded in multi-attribute decision making and explicitly explores the consequences of different value functions and weightings assigned by stakeholders. Kempener (2008) has applied this method in agent-based models to determine the robustness of interventions to stimulate sustainable development of bioenergy networks in South Africa.

SBGP requires two steps. Firstly, it requires a number of performance criteria for evaluating the different network evolutions to be structured into an objective hierarchy. Secondly, preference information on the importance of the criteria needs to be provided, by, for example, the use of trade-off or swing weightings methods, denoting the relative importance of a swing between best and worst performance within, and between, each scenario (Durbach and Stewart 2003:266).

The use of SBGP allows for evaluating the robustness of interventions over a range of performance criteria. There are two sets of performance criteria suggested for the evaluation of rural sustainable development. Firstly, there are static performance criteria reflecting the economic, environmental and social contribution of the agricultural supply chains to rural development at any point in time throughout the analysis. The second category consists of dynamic performance criteria. These criteria reflect how resilient and adaptive the structure of the agricultural supply chains within the regions is to potential external disturbances. These external disturbances could consist of shocks (ie rapid disturbances) or shifts (gradual changes in the environment). A framework to evaluate the dynamic features of network structures is developed by Stirling (Stirling, et al. 2007).

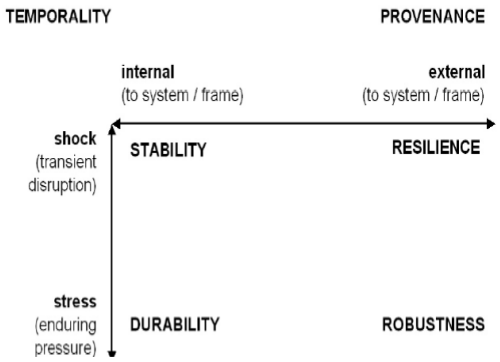

Fig. 6. *Dynamic system properties – across time (temporality) and origin (provenance) (Scoones, et al. 2007)*

Both static and dynamic performance criteria can be combined to assess the consequences of policy interventions. This means that policy interventions are not only assessed according to the benefits they generate for the region at any point in time, but also whether the policy instruments makes the region more or less vulnerable to external disturbances. By combining both sets of criteria, it is possible to provide a more comprehensive analysis of the impacts of policy interventions on rural development. Furthermore, it allows for explicit consideration of how different stakeholders might value static performance criteria over dynamic performance criteria.

7. Conclusions

This paper has proposed a novel methodology to use ABM in the evaluation of policy interventions for rural development. The methodology suggests an empirical basis for the development of ABM, which allows for exploring the importance of regional diversity in assessing the consequences of policy interventions. Secondly, the methodology proposes scenario analysis to explore how different 'mental models' employed by farmers and other supply chain actors might impact on the effectiveness of policy interventions for stimulating rural development. The use of 'behavioural rule scenarios' reduces the reliance on accurate data to represent the current state of the system and the impact of the analyst on the modelling outcomes. Instead, the focus in the scenario analysis is on how actors within the region might deal with the uncertainty associated with information rather than the uncertainty in the information itself. This approach reduces the reliance on the analyst for interpreting the uncertainty within his/her models and increases the robustness of the analysis (Reusser, et al. 2004:6). Finally, it is suggested to use the ABM results for evaluating the robustness of policy interventions to stimulate rural development over a range of static and dynamic performance criteria in a range of diverse regions within Europe.

References

Albisser, G. and Lehmann, B. 2007 'Agent-based Modeling of Structural Change in Agriculture: Experiences from the Implementation of Cooperation and Collaboration' *1st Mediterranean Conference of Agr-Food Social Scientists*, Barcelona, Spain.

Ansoff, H. I. 1965 *Corporate Strategy : An Analytic Approach to Business Policy for Growth and Expansion.* , New York: McGraw-Hill.

Balmann, A., Happe, K., Kellermann, K. and Kleingarn, A. 2002 'Adjustment costs of agri-environmental policy-switchings', in M. A. Janssen (ed) *Complexity and Ecosystem Management: The Theory and Practice of Multi-AGent Systems*, Cheltenham, Uk: Edward Elgar.

Bourdieu, P. 2003 *The Social Structure of the Economy*, Oxford: Polity.

Brunner, R. D. 1999 'Predictions and policy decisions', *Technological Forecasting and Social Change* 62(1-2): 73-78.

Burton, R. J. F. 2004 'Reconceptualising the 'behavioural approach' in agricultural studies: a socio-psychological perspective', *Journal of Rural Studies* 20(3): 359-371.

Burton, R. J. F. and Wilson, G. A. 2006 'Injecting social psychology theory into conceptualisations of agricultural agency: Towards a post-productivist farmer self-identity?' *Journal of Rural Studies* 22(1): 95-115.

Castello, L., Viaggi, D. and Zanni, G. 1997 'Agri-environmental policies and protected areas: a case study in the "Parco del Taro", Parma (Italy)' *52nd EAAE Seminar: Typical and Traditional Production: rural effect and agro-industrial problems*, Parma, Italy.

Cioffi-Revilla, C. and Gotts, N. M. 2003 'Comparative Analysis of Agent-based Social Simulations: GeoSim and FEARLUS Models' *"Model-2-Model" Workshop on Comparing Multi-Agent Based simulation Models*, Marseilles, France: Claudio Cioffi-Revilla and Macaulay Institute.

Conlisk, J. 1996 'Why bounded rationality?' *Journal of Economic Literature* 34(2): 669.

Deffuant, G., Huet, S. and Amblard, F. 2005 'An Individual-Based Model of Innovation Diffusion Mixing Social Value and Individual Benefit', *The American Journal of Sociology* 110(4): 1041-1069.

DiMaggio, P. J. and Powell, W. W. 1983 'The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields', *American Sociological Review* 48(2): 147-160.

Durbach, I. and Stewart, T. J. 2003 'Integrating scenario planning and goal programming', *Journal of Multi-Criteria Decision Analysis* 12(4-5): 261-271.

Franks, D. W., Kaufmann, P. and Stagl, S. accepted 'Simulating the Diffusion of Organic Farming Practices in Two New Eu Member States', *Ecological Economics*.

Giddens, A. 1984 *The Constitution of Society*, Berkeley, Los Angeles: University of California Press.

Gigerenzer, G. and Goldstein, D. G. 2000 'Reasoning the Fast and Frugal Way: Models of Bounded Rationality', in T. Connolly, H. R. Arkes and K. R.

Hammond (eds) *Judgement and Decision Making*, 2nd edition Edition, Cambridge, New York, Melbourne: Cambridge University Press.

Happe, K., Kellermann, K. and Balmann, A. 2006 'Agent-based Analysis of Agricultural Policies: an Illustration of the Agricultural Policy Simulator AgriPoliS, its Adaptation and Behavior', *Ecology and Society* 11(1): 49.

Hare, M. and Deadman, P. 2004 'Further towards a taxonomy of agent-based simulation models in environmental management', *Mathematics and Computers in Simulation* 64(1): 25-40.

Haunschild, P. R. and Miner, A. S. 1997 'Modes of Interorganizational Imitation: The Effects of Outcome Salience and Uncertainty.' *Administrative Science Quarterly* 42(3): 472-500.

Jager, W. 2000 'Modelling Consumer Behaviour' *Psychological, Pedagogical and Sociological Sciences*, Vol. PhD, Groningen, the Netherlands: University of Groningen.

Janssen, M. A. and Ostrom, E. 2006 'Empirically Based, Agent-based models', *Ecology and Society* 11(2): art. 37.

Jungermann, H. and Thuring, M. 1987 'The Use of Mental Models for Generating Scenarios', in G. Wright and P. Ayton (eds) *Judgmental Forecasting*, Chichester, UK: John Wiley & Sons Ltd.

Kempener, R. 2008 'From Organisational Behaviour to Industrial Network Evolution: Stimulating Sustainable Development of Bioenergy Networks in Emerging Economies' *School of Chemical And Biomolecular Engineering*, Sydney, Australia: University of Sydney.

Kempener, R., Cohen, B., Basson, L. and Petrie, J. 2008 'A Framework for Analysis of Industrial Networks', in B. Davidsdottir and M. Ruth (eds) *The Dynamics of Regions and Networks in Industrial Ecosystems*: Edward Elgar, in press.

Lempert, R. J., Groves, D. G., Popper, S. W. and Bankes, S. C. 2006 'A General, Analytic Method for Generating Robust Strategies and Narrative Scenarios', *Management Science* 52(4): 514-528.

Lobianco, A. 2008 'RegMAS User Manual: Version 1.2.0', Ancona, Italy: Department of Economics, Marche Polytechnic University.

Lynne, G. D., Franklin Casey, C., Hodges, A. and Rahmani, M. 1995 'Conservation technology adoption decisions and the theory of planned behavior', *Journal of Economic Psychology* 16(4): 581-598.

Lynne, G. D., Shonkwiler, J. S. and Rola, L. R. 1988 'Attitudes and Farmer Conservation Behavior', *American Journal of Agricultural Economics* 70(1): 12.

Matthews, R. B., Gilbert, N., Roach, A., Polhill, J. G. and Gotts, N. M. 2007 'Agent-Based Land-Use Models: A Review of Applications', *Landscape Ecology* 22(10): 1447-1459.

Mintzberg, H. and Lampel, J. 1999 'Reflecting on the Strategy Process', *Sloan Management Review* 40(3): 21-30.

Mitchell, R. 2006 'Study on Identifying Rural Sociological Barriers to Adoption', Edmonton, Alberta: Alberta Research Council.

Nelson, R. R. and Winter, S. G. 1982 *An Evolutionary Theory of Economic Change*.

Parker, D. C., Manson, S. M., Janssen, M. A., Hoffmann, M. J. and Deadman, P. 2003 'Multi-Agent Systems for the Simulation of Land-Use and Land-Cover Change: A Review', *Annals of the Association of American Geographers* 93(2): 314 - 337.

Ploeg, J. D. v. d. 1994 'Styles of Farming: An introductory note on concepts and methodology', in J. D. v. d. Ploeg and A. Long (eds) *Born From Within: Practice and Perspectives of Endogenous Rural Development*, Assen, the Netherlands: Van Gorcum.

Podolny, J. M. 1994 'Market Uncertainty and the Social Character of Economic Exchange.' *Administrative Science Quarterly* 39(3): 458-483.

Polhill, J. G., Adam, B., Gotts, N. M., Izquierdo, L., Law, A. and Parker, D. C. 2007 'FEARLUS Model 0-6-8+ELMM-0-2', Aberdeen, UK: Macaulay Institute, Center for Social Complexity George Mason University.

Reusser, D. E., Hare, M. and Pahl, C. 2004 'Relating Choice of Agent Rationality to Agent Model Uncertainty - an experimental study', in C. Pahl-Wostl, S. Schmidt and T. Jakeman (eds) *Complexity and Integrated Resources Management*, iEMSs 2004 International Congress Edition, Osnabrueck, Germany: International Environmental Modelling and Software Society.

Schoemaker, P. J. H. 1993 'Multiple scenario development: Its conceptual and behavioral foundation', *Strategic Management Journal* 14(3): 193.

Scoones, I., Leach, M., Smith, A., Stagl, S., Stirling, A. and Thompson, J. 2007 'Dynamic Systems and the Challenge of Sustainability' *STEPS Working Papers*, Brighton, UK: STEPS Centre.

Shucksmith, M. and Herrmann, V. 2002 'Future Changes in British Agriculture: Projecting Divergent Farm Household Behaviour', *Journal of Agricultural Economics* 53(1): 37-50.

Simon, H. A. 1990 'Invariants of Human Behaviour', *Annual Review of Psychology* 41: 1-19.

Sterman, J. D. 2000 *Business Dynamics, Systems thinking and Modeling for a Complex World*, Boston: Irwin McGraw-Hill.

Stirling, A., Leach, A., Mehta, M., Scoones, I., Smith, A., Stagl, S. and Thompson, J. 2007 'Empowering Designs: Towards a More Progressive Appraisal of Sustainability' *STEPS Working Paper*, Brighton, UK: STEPS Centre.

Vanclay, F., Mesiti, L. and Howden, P. 1998 'Styles of Farming and Farming Subcultures: Appropriate Concepts for Australian Rural Sociology', *Rural Society* 8(2): 85-125.

Weisbuch, G. and Boudjema, G. 1999 'Dynamical aspects in the adoption of agri-environmental measures', *Advances in Complex Systems* 2(1): 11-36.

Whatmore, S. J. 1994 'Farm Household Strategies and Styles of Farming: Assessing the Utility of Farm Typologies', in J. D. v. d. Ploeg and A. Long (eds) *Born from Within: Practice and Perspectives of Endogenous Rural Development*, Assen, The Netherlands: Royal van Gorcum.