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Are agricultural land use patterns influenced by farmer imitation?

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Abstract

This paper proposes a methodology based solely on spatial data to analyse whether and, to what extent, farmer imitation leaves an observable footprint on an agricultural landscape. Geographical Information System (GIS) analysis of parcel and farm location data of a study region in central Belgium was developed as an alternative methodology to farmer interviews. Results suggest that imitation is not an important determinant of agricultural land use patterns in the study area. The effect of imitation on landscapes is limited to the extent of being hardly significant. Neighbouring parcels cultivated by farmers who live in close proximity are only slightly more similar than neighbouring parcels cultivated by farmers who live further away from one another. The results question the validity of the assumptions underlying agent-based models that try to explain agricultural land use through imitation behaviour.

The results should, however, be considered with caution as the proposed methodology has two limitations. First, comparison between neighbouring parcels could not identify the imitation effect from all factors that influence agricultural land use. Relative space was not accounted for, which led to two possible explanations for the similarity of neighbouring parcels: imitation or the location of a parcel relative to the farm. Secondly, the method was applied to aggregated land use classes for a single year, which did not allow for the effect of crop rotations in understanding imitation behaviour.

Keywords: Imitation; Agricultural land use; Farmer proximity; Agent-based model; Equi-finality

1. Introduction

In modelling agricultural land use and land cover distributions using an optimisation approach, Rounsevell et al. (2003) generated patterns of land use that were more spatially-distributed than the reality. They attributed this observation to the influence of neighbouring land uses on farmer choices (e.g. White and Engelen, 1993, 1997) that were thought to create more concentrated land use patterns in reality. This process can result in actual land use distributions being significantly different from those, which might be expected from a knowledge of the physical conditions (soils and climates) and economic factors alone. When making decisions about land use and management, farmers have to cope with large uncertainties related to price and cost fluctuations, weather variability and policy change. Their behaviour is typified by multidimensional optimisation rather than a rational-actor-approach. When faced with uncertainties, farmers seek robust solutions that often put into play adaptive social processes (Festinger, 1954; Lempert, 2002) such as imitation.

Farmers engage in imitation and repetitive behaviour (habits) to efficiently use their limited cognitive resources (Jager et al., 2000). Habits describe the repetition of their originally deliberate choices for as long as the outcomes are satisfying (Jager et al., 2000). Imitation is an automatic social process, which relates to the theories of social learning (Bandura, 1977, 1986) and normative conduct (Cialdini et al., 1991). Social learning theory states that watching another person being rewarded for understandable and reproducible behaviour may result in the imitation of that behaviour (Jager et al., 2000). Imitation has been studied as part of the diffusion of innovation process (Ryan and Gross, 1943; Hägerstrand, 1967). Adaptation of an innovation depends on the characteristics of the innovation

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itself, the characteristics of the innovators (actors), and the characteristics of the environmental context (Wejnert, 2002). Examples of farmer imitation behaviour include the adoption of hybrid corn varieties (Ryan and Gross, 1943), conservation tillage practices (Warriner and Moul, 1992), new fertilizer (Feder and Umali, 1993) or grassland management practices (Hägerstrand, 1967). Diffusion processes strongly affect agriculture (Hägerstrand, 1967), which suggests that private information and local social networks are especially important in rural areas (Reimer, 1997; Hofferth and Iceland, 1998; Lindsay et al., 2005). The exchange of information between individuals has been found to be important for innovation decisions (Berger, 2001) and imitation is known to be a method that land managers use in choosing between various options (Pomp and Burger, 1995). Imitation can be understood as a strategy to economise cognitive efforts, and/or to compensate for an absence of knowledge (Jager et al., 2000). Imitation strategies are based on the observation of successful land uses or techniques (and conversely, avoidance of innovations that are seen to fail). Farmers rely on information from past decisions – their own and those of other agents – to update decision-making strategies (Parker et al., 2002). At the most critical stages in their decision process, farmers rely on information brought to them by their peers (Berger, 2001). Buttel et al. (1990) state that farmers' decisions were affected by the opinions and advice of neighbouring farmers. Lowe et al. (1990) also found that farmers tend to give more importance to sources of information that derive from the farming community than elsewhere. The public nature of farming favours farmer imitation strategies (Newby et al., 1978). Farming is a very visible activity – visible, to other local inhabitants, to anyone who passes through the countryside and more importantly to other farmers.

The existence and observation of a neighbourhood effect has led to the development of land use and land use change models that integrate, implicitly, social and behavioural factors into cellular automata (CA) and agent-based models (ABM) (Verburg et al., 2004; Engelen et al., 2002; White and Engelen, 1997; Berger, 2001; Batty et al., 1997; Caruso et al., 2005). Most CA and ABM are, however, still theoretical. For example, the Framework for the Evaluation and Assessment of Regional Land Use Scenarios (FEARLUS) approach used a simple, but abstract agent-based model to explore in a spatially explicit way the performance of imitative versus non-imitative strategies of land use selection by land managers (Gotts et al., 2003). The model showed that the success of a range of different imitative strategies depended on the context in which imitation takes place. Performance depends on the strategies being followed by other agents and various aspects of the spatio-temporal heterogeneity of the environment: the balance between spatial and temporal variability, the predictability of variations over time, and the scale of spatial heterogeneity (Polhill et al., 2001).

The incorporation of a micro-level perspective on human behaviour within integrated models of land use and land use change would potentially provide a better understanding and eventual management of the processes involved in the formation of landscape patterns (Jager et al., 2000). However, a wide gap remains between the theoretical implications of agent-based models (ABM) and empirical data (Parker et al., 2003). It is difficult to parameterise and validate ABM due to their large data requirements (Verburg et al., 2001). A model of a complex land use system has many parameters that change both in space and in time, which require calibration and validation data at a high spatial and temporal resolution. The lack of individual data limits ABM model validation (Parker et al., 2003). Furthermore, multi-agent models are often built on anecdotal evidence because of the problem of equi-finality (or multi-causality) that cannot always be resolved though calibration. The same final state or condition of a system may be reached from different initial conditions (inputs) and in different ways (transformations). It is difficult to find unequivocal empirical evidence for the very micro-level laws that give the models their richness (Jager et al., 2000). With different techniques, an infinite number of models can be created, whilst reality remains constant. It is possible to develop a model that can reproduce a statistically correct meta-phenomenon with a model structure that does not capture any real processes (Parker et al., 2003).

Taking advantage of the availability of detailed spatial data, the research presented in this article addresses the validity of the assumptions about imitation that underpin many agent-based models of agricultural land use. More generally, the objective of this paper was to propose a methodology based solely on spatial data to analyze whether and, to what extent, farmer imitation leaves an observable footprint on land use in an agricultural landscape. The goal was to gain insight into farmer imitation from the Geographical Information System (GIS) analysis of parcel and farm location data only. This is proposed as an alternative (and complimentary) methodology to most studies of social processes that use interviews or surveys (Ryan and Gross, 1943; Stockdale, 2002; Chiffoleau, 2005; Lindsay et al., 2005). The basic principle of the methodology was to test whether the land use of neighbouring parcels cultivated by farmers living close to one another were more similar than neighbouring parcels of farmers who are separated by greater distances. The methodology relied on two assumptions. First, the socio-informational networks of farmers decay with distance (Ryan and Gross, 1943; Hägerstrand, 1967; Lindsay et al., 2005). Thus, the distance between farms determines the frequency of interactions and the quantity of information exchanged between farmers. If imitation influences agricultural land use patterns, then the distance between farms cultivating two neighbouring parcels should influence the similarity of those parcels. The second assumption was that analysing neighbouring parcels allows the control of all other factors (such as physical and political factors) that influence agricultural land use. In comparing neighbouring