A Multi-Agent Model Simulating Agronomic Income Sources in the North China Plain - Case study for Quzhou county

Andreas Roth[1], Reiner Doluschitz[1]

[1]Dept. of Farm Management, Institute of Business Management and Computer Applications in Agriculture (410c), University of Hohenheim

Abstract

The North China Plain (NCP) administratively covers the Hebei province border and neighbouring provinces and is located in the north-eastern part of the Peoples Republic of China. This plain is the most productive cropping area achieving highest national cereal yields and applying extreme high production intensities. However these yields are achieved with enormous human and ecological tradeoffs which led to sidekicks, e.g. water shortages. A Multi-Agent model was successfully created to primarily focus on the income factors soil, crop area and yield. The primary goal was to simulate inter-agent (alias farmer) competition on county surface. Results show a high temporal variability and a trend to different agent production levels according to income factors. Beside these the yield level is highly variable to in temporal terms. Agricultural income depends not only on yield situation and revenues as well as sales volume factors must be further differentiated.

Introduction

Farmer incomes in the North China Plain are highly variable considering the agronomic situation each agricultural year. However, environmental and economic side-factors influence the actual yield situation and the upcoming growing season. Budget calculations of farmers, e.g. for fertiliser are annually highly variable, too. These together affects the frame conditions of cultivated land in the North China Plain (NCP) tremendously [1]. Additionally the recently socio-economic innovations by Chinese government change the public anticipation of agriculture and propagates, e.g. the probability of “off-farm” income [2]. This together with a growing urbanisation rate is believed to aggravate the aerial features of Hebei province agricultural landscapes.

In order to investigate the spatial features of agricultural activities we identified the farmer decision to generate income as the key research variable. Factorial impact on income is achieved e.g. by the rate of urbanisation or percentage of off-farm income and specific data e.g. on household structure. Further more the size and crop composition of (alternating) arable land is an important issue to consider. Hence in order to depict future spatial patches of agriculture in Hebei province it is inherent to analyse different paths of development.

Methodological Approach

The designation of a local version of the agent model *NetLogo* a cross-platform computing environment was created for our purposes [9]. The programming language is *Java*. The program is structured by sub-routines defining variables, patches and agents. Primarily geo-referenced data derived by GIS analysis (*IDRISI*) and data base [3], e.g. soils and infrastructural data at county level are included. We focus this work to the county Quzhou which is located in south-eastern part of Hebei province. These data sets provide a unique geo-data basis on which agent-simulations will be conducted [5]. Secondly agents are introduced [4] acting at the residential areas found in the research area. These agents are individually configured by household and agronomic variables and have pre-defined radii of activity. Variables considered to primarily affect income and yield are labour, household size, crop area, percentage of “off-farm”, leased and under-leased land. These data sets are extracted out of household surveys conducted in the study region by project partners. These surveys had been of different topics, e.g. economic structure of households, agricultural management or ecological survey. Our approach accounts for zones of interactivity between agents. These areas are of special interest as representatives of competition and convergence fields in the inter-agent-relationship. The multi-agent spatial approach was chosen to simulate inter-farmer decision making with diverse constitution of households and external driving factors, e.g. the off-farm income. Expected outcomes of this study will be predicted yield and income and the identification of pathways and interconnected relationships of agent decisions generating these two.

Results

First we created a geo-referenced GIS Data set which was implemented in order to set up the environmental conditions [7]. GIS Data consisting e.g. of a soil map was derived by spatial analyses and will be used for probability calculations of side conditions (e.g. distance to markets) alternating the income situation. Next a farmer agent set primarily based on village dispositions in the area was included. On this basis a random 3km radius was involved for each agent in order to scope for areas of interference, e.g. for rented land and to create further an additional income source for each individual farmer (agent) plus the incorporated yield determination by fruit and soil type. Each farmer was parameterised by a set of variables. These variables are either a f_x function with an unique value or probability functions (see above). Together these variables are used to calculate farmer income. Temporal time steps *t* of the Model MAS *Quzhou* is expressed as ticks. These ticks are routine calculation intervals representing time *t*. After resetting variable values for growth versus time

simulation the two target farmers depicted different levels of growth dynamics. As expected higher yield levels [kg ha^{-1}] was achieved by farmer with higher stock reserves. These stocks at values of 0.4 (1^{st} agent) and 0.6 (2^{nd} agent) are used for the supplementation of cultivation activities. In the later progress of MAS *Quzhou* simulations these stock procedures might be use full to incorporate fertilizer or machinery activities. The goal was to develop constant growth dynamics in a Chinese rural cultivation scheme with multiple interference factors on farmer income.

Discussion

Since the model MAS *Quzhou* so far is able to simulate two agents growth and yield dynamics only, conclusions are limited. Constant growth dynamics at two different levels derived with individual input factors however made it possible to extract an insight view on each production scheme individually. The program structure gives us the opportunity to assess at different thresholds in order to optimize step by step the agents (farmer) individual income influences. Finally agent income which is affected by so many inherent (family structure etc.) and spatial (streams etc.) variables must be carefully observed. Furthermore the thresholds must be defined in a serious margin of fluctuations and further investigated and discussed. A higher level of complexity is desired and more factors and more actors will be included in the future.

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