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The distribution of landed property

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ABSTRACT

The distribution of property is established through various mechanisms. In this paper we study the acreage distribution of land plots owned by natural persons in the Zlín Region of the Czech Republic. We show that the data are explained in terms of a simple model in which the inheritance and market behavior are combined.

1. Introduction

Quantitative study of human behavior requires reliable data and tools to analyze them. The latter improved dramatically in recent years when entries in various databases became available in a digital form. From the sociological point this opens a way to new highly interesting empirical findings and theoretical endeavors to understand them.

One of the first publicly available records were the telephone books which gave an opportunity to study the distribution of surnames. Interpreting the results in a model setting, the recent records found in the telephone book are understood as a result of a long process of intermarriages and surnames inheritability, hence the surname statistics refers to social and population processes in the past [1]. In particular, it is known that the number of individuals sharing the same surname follows a scaling rule known as Zipf law. Let us arrange the surnames in the descending order with respect to the number of entries found in the telephone book, and let $N(1)$ denote the number of records found for the most frequent surname, $N(2)$ the number of records for the second widespread surname, etc.; then the Zipf law says that $\log(N(k)) \approx -c\log(k)$ with some constant c.

The mechanism of inheritance from a single parent appears not only in the social context: similarly to surnames it applies to nonrecombining alleles in the genome, hence it is not surprising that there is a close link between the surname distribution and the human genome [2]. Furthermore, such a situation is not restricted to surnames but applies also to groups of people sharing a common native language, to the species diversity in ecological systems and so on – cf. Ref. [3]. It demonstrates that cultural traditions are transmitted from the ancestors to the descendants through a process analogous to the genetic heredity

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and display a close parallelism between the cultural and biological evolution – recall that in the evolutionary psychology these mechanisms are studied under the name "memetics" [4,5].

In the field of economics the power law distribution is traditionally named after the classical work [6] of Vilfredo Pareto; it is used to describe phenomena such as the statistics of personal income, or the allocation of wealth in a steady society [7,8], however, also fluctuations of the stock prices or the land estate display such a behavior [9,10].

Also the urban grows patterns display this behavior. Based on a correlated percolation the urban growth has been described in Refs. [11,12] and compared with the growth of the city of Berlin. Another approach is based on the spatial trade network with land areas in the city – see Ref. [13].

Our aim in this paper is to combine these two aspects into a single model capable of describing situations in which both the ancestor–descendant dynamics and the market behavior occur. Specifically, we will analyze the distribution of the sizes of land plots owned by individuals. It is clear that – in contrast to a corporative ownership – a natural person can acquire the land either on the real estate market or to inherit it. On the one hand the land is transmitted from an ancestor his/her descendant similarly like surnames, on the other hand it is a subject to changes by acquiring/selling the land on the real estate market. We are going to demonstrate that such a complex human behavior can be reasonably well described by a simple mathematical model.

The empirical basis for our investigation are data obtained from the *Czech Office for Surveying, Mapping and Cadastre* describing the present status of the legal relations to real estate property in the Czech republic. This includes, in particular, the information about the sizes, types, geographical location, and owners of the individual land plots; here we focus on the statistical distribution of the plot sizes owned by individuals.

The idea to use cartographic data is not new. For instance, the information on the spatial structure of the urban networks has been used in Ref. [14] to analyze the distribution of vehicular flows. There are also direct attempts to model future developments of the land use – in particular in the urban regions – such an information is of value especially for the real estate developers. These models, however, are not simple – see, e.g., Ref. [15] for a cellular automaton approach. Our intention in the present work is more simple: we are going to describe the actual division of the surface of (a part of) the Czech Republic territory among individuals as a steady state resulting from a long-term process of real estate inheriting and trading. Needless to say, we do not care about the individual plot sizes, only about their statistical properties.

Let us describe briefly the contents of the paper. In the next section we present and discuss a simple land trading/inheritance model. The resulting statistical properties of the plot sizes will be then compared with the true cadastral data for the Zlín region in Section 3.

2. A simple real estate trading/inheritance model

To motivate the model, note first that the Czech cadastral records, which we work with, do not contain the land plot history, and consequently, the past real estate transfers cannot be directly extracted from them. There are indirect clues that contain information on carried transfers: any conveyance of real estate for consideration is subject to the real-estate-transfer tax. On the other hand, the inherited or donated realties are liable to the estate and capital transfer tax. Unfortunately, this tax is levied on all assets which makes the information about inherited realties obscured. Nonetheless, the taxing information represents the process of realty conveyance in the metric of the current prices. Recall that the price metric was used, for instance, to analyze the mechanism leading to the crash of the Japanese land market at the end of eighties – see Ref. [16]. It does not say much, however, about the actual acreage of the plots and about its historical development. Another factor which makes its use questionable is that the land price is subject to unpredictable fluctuations; to quote an example from the same study, the mean price of one square meter of land in Japan increased in the years 1983–1993 nearly sevenfold [16]. The dynamics of land prices exhibits a volatility which makes it difficult to describe – we refer to Ref. [17] and the references therein for more details.

With these facts in mind, we will focus on the statistical properties of the acreage of the land plots (cadastral units). They represent better objects to study because the plot sizes change little in the course of time and do not yield to market fluctuations. Most often the whole plot is conveyed and its size does not change at all; changes of the plot size are rare and are always related to a new surveying. The latter is typically a complicated and costly procedure, which is one more reason why the acreage is not vulnerable to speculations.

We understand the recent records contained in the land registry as a description of a steady state resulting from a long series of land inheritance and land trading. The total acreage is preserved, of course, and can be only redistributed among the new owners. We are going to describe the steady state by an agent-based approach developed originally to model the wealth of closed economies – see Ref. [18] for a review. For the sake of simplicity we will use the most elementary version designed initially to describe the social stratification – see Ref. [8] – it is also known as the "inequality process".

As usual in such a situation we use discrete time proceeding in steps typical for an ownership change; one can think of them as of generations. Let $S_k(n)$ denote the acreage of the cadastral unit k at time n and $S_{k+1}(n)$ be the the acreage of its geometrical neighbor, by that we mean that $S_k(n)$ and $S_{k+1}(n)$ have a common border. Then the model cadastral dynamics we propose proceeds to the next generation in the following way,

$$\begin{aligned} S_k(n+1) &= \lambda S_k(n) + a\,((1-\lambda)S_k(n) + (1-\mu)S_{k+1}(n)) \\ S_{k+1}(n+1) &= \mu S_{k+1}(n) + (1-a)\,((1-\lambda)S_k(n) + (1-\mu)S_{k+1}(n)) \end{aligned} \tag{1}$$