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A family-network model for wealth distribution in societies

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Abstract

A model based on first-degree family relations network is used to describe the wealth distribution in societies. The network structure is not a priori introduced in the model, it is generated in parallel with the wealth values through simple and realistic dynamical rules. The model has two main parameters, governing the wealth exchange in the network. Choosing their values realistically, leads to wealth distributions in good agreement with measured data. The cumulative wealth distribution function has an exponential behavior in the low and medium wealth limit, and shows the Pareto-like power-law tail for the upper 5% of the society. The obtained Pareto indexes are in good agreement with the measured ones. The generated family networks also converge to a statistically stable topology with a simple Poissonian degree distribution. On this family network many interesting correlations are studied, and the main factors leading to wealth diversification and the formation of the Pareto law are identified.

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1. Introduction

Since the seminal work by Vilfredo Pareto [1], it is known that the wealth distribution in capitalist economies shows a very peculiar and somehow universal functional form. In the range of low income, the cumulative distribution of wealth (the probability that the wealth of an individual is greater than a given value) may be fitted by an exponential or log-normal decreasing function, while in the region containing the richest part of the population, generally less than 5% of the individuals, this distribution is well characterized by a power-law (see for example Ref. [2] for a review). This empirical behavior has been confirmed by a number of recent studies on the economy of several corners of the world. The available data are coming from so far apart as Australia [3], Japan [4,5], the US [6], continental Europe [7,8] or the UK [9]. The data are also spanning so long in time as ancient Egypt [10], Renaissance Europe [11] or the 20th century Japan [12]. Most of these data are based on the declaration of income of the population, which is assumed to be proportional to the wealth. There are however some other databases obtained from different sources like for instance the area of the houses in ancient Egypt [10], the inheritance taxation or the capital transfer taxes [13]. The results mostly back Pareto's conjecture on the shape of the wealth distribution. The interesting problem that remains to be answered is the origin of the peculiar functional trend.

The answer to this question is a long-standing problem, which even motivated some of the initial Mandelbrot's and Simon's work 50 years ago. Let $P_>(w)$ be the probability of having a wealth higher than w. Pareto's law then establishes that the tail of $P_>(w)$ decays as

$$P_>(w) = \int_w^\infty P(w')\,\mathrm{d}w' \sim w^{-\alpha}\,,$$

where α is the so-called Pareto index and $P(w)$ the normalized wealth distribution function. Typically, the presence of power-law distributions is a hint for the complexity underlying a system. It is however important to notice that in spite of what happens with most exponents in statistical physics, α may change in time depending on the economical circumstances [5,12], making thus impossible the definition of some sort of universal scaling in this problem. This aspect is a key characteristic that any model on wealth distribution should be able to reproduce.

Economical models are essentially composed of a group of agents placed on a lattice that interchange money following pre-established rules. The system will eventually reach a stationary state where some quantities, as for instance the distribution $P_>(w)$, may be measured. Following these ideas, Bouchaud and Mézard [14] and Solomon and Richmond [15,16] separately proposed a very general model for wealth distribution. This model is based on a mean field type scenario with interactions among all the agents and on the existence of multiplicative fluctuations acting on each agent's wealth. Their results on the wealth distributions adjust well to the phenomenological $P_>(w)$. Roughly, the same conclusions were obtained by Scaffeta et al. [17], who considered a nonlinear version of the model and from other regular lattice-based models as those in Refs. [18,19]. This kind of models defined on