Prospects for Money Transfer Models

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Summary. Recently, in order to explore the mechanism behind wealth or income distribution, several models have been proposed by applying principles of statistical mechanics. These models share some characteristics, such as consisting of a group of individual agents, a pile of money and a specific trading rule. Whatever the trading rule is, the most noteworthy fact is that money is always transferred from one agent to another in the transferring process. So we call them money transfer models. Besides explaining income and wealth distributions, money transfer models can also be applied to other disciplines. In this paper we summarize these areas as statistical distribution, economic mobility, transfer rate and money creation. First, money distribution (or income distribution) can be exhibited by recording the money stock (flow). Second, the economic mobility can be shown by tracing the change in wealth or income over time for each agent. Third, the transfer rate of money and its determinants can be analyzed by tracing the transferring process of each one unit of money. Finally, money creation process can also be investigated by permitting agents go into debts. Some future extensions to these models are anticipated to be structural improvement and generalized mathematical analysis.

Key words: Transfer model, Distribution, Mobility, Transfer rate, Money creation

1 Introduction

Money does matter to an economy. To understand the role that money plays in the performance of economic system, many theoretical studies have been performed in traditional economics. Recently, a small branch of “econophysicists” shifted their attentions to this issue. Several models have been developed by applying principles of statistical mechanics to the questions of income and wealth distribution [1, 2, 3, 4, 5]. These models share some characteristics, such as consisting of a group of individual agents, a pile of money and a specific trading rule. The most noteworthy fact is that money is always transferred from one agent to another in the transferring process. So this kind of models could be referred as money transfer models. The prime theme of constructing such models is to explore the mechanism behind wealth or income
distribution. In fact, they can be applied more widely in some other economic issues. In this paper, we prospect for some applications of these transfer models and anticipate that considerable achievements can be made on the basis of them. We also argue that further improvements should be accomplished to make these models much more realistic.

The purpose of this paper is to identify what issues could be analyzed on the basis of money transfer models. This kind of models is very easy to grasp, for only two elements are involved: money and agents. Money is possessed or held by agents, and may be transferred among them via trading. Based on these models, recent efforts were mainly devoted to the formation of monetary wealth distribution, the circulation of money [6, 7] and creation of money [8]. We would like to summarize and expand the scope of their applications in the following four routes.

2 Applications

2.1 Distribution

Money transfer models are originally used to demonstrate steady distributions of money. This can be achieved by recording the quantity of money stock possessed by each agent in the simulations. In the basic model proposed by A. Drăgulescu and V.M. Yakovenko, the money distribution follows a Boltzmann-Gibbs law [1]. B.K. Chakrabarti et al. introduced the saving behavior into the model [2, 3], and found the money distribution obeys a Gamma law when all the agents are set with the same saving factor, but a power law as the saving factor is set randomly. N. Ding et al. introduced the preferential dispensing behavior into the trading process and also obtained a stationary power-law distribution [4]. From these results we can see that the shape of distribution is determined by the trading rule.

Besides these theoretical studies, econophysicists also performed the empirical studies on the distribution in the economy, following the earlier Pareto’s work. The analysis showed that in many countries the income distribution typically presents with a power-law tail, and majority of the income distribution can be described by an exponential distribution [9, 10, 11]. It is worthy noting that account of these empirical studies is taken of income distribution. Income corresponds to money flow which is different from money amount. However, all the distributions presented in previous simulations do not refer to the money flow. Actually, in the money transferring process, we can also record the level of money flow received by each agent during a given period. The statistics of them yields the flow type distribution. Thus, embodying the money flow generation mechanism, the transfer models can also provide a convenient tool for investigating the mechanism behind the income distribution in reality.
2.2 Mobility

During the simulations of money transfer models, the amount of money held by agents varies over time. This phenomenon is called mobility in economics. In the view of economists, mobility is an indispensable supplement to distribution because the former can cure the anonymity assumption of the latter [12]. And the analysis of mobility is greatly helpful to comprehend the dynamic mechanism behind the distribution. In addition, like distribution, economic mobility should be an essential criterion when evaluating a relevant theoretical model.

In the transferring process, the economy will reach its steady state and the distribution will keep unchanged. After that, the amount of money still fluctuates over time for each agent, meanwhile the rank of each agent shifts from one position to another. To show the mobility phenomenon with clarity, we can record agents’ rank instead of the amount of money. The time series of rank for any agent’s can be obtained by sorting all of agents according to their money in the end of each round. We performed some simulations and the primary results show all of agents are equal in the economies of models in Ref. [1] and [2]. They have the same probability to be the rich or the poor. It can be found that the frequency of the rank fluctuation decreases as the saving rate increases. By contrast, the economy in Ref. [3] is stratified where agents are not equal any longer for their saving rates are set diversely. Based on these results, it can be concluded that different models exhibit different mobility characters.

2.3 Transfer Rate

In reality, money does not remain motionless. Instead, it is transferred from hand to hand consecutively. This phenomenon is called the circulation of money in economics. The term usually used to describe the circulation is the velocity of money, which can be computed by the ratio of total transaction volume to the money stock. In fact, it refers to the transfer rate of money that measures how fast the money moves between agents. This rate can be observed by recording the time intervals for each unit of money to be held. This kind of time interval is called ”holding time” or ”latency time” of money. It can be found that there is not only a distribution of money among agents, but also a steady distribution of holding time as the economy reaches its equilibrium state. The holding time distribution also shifts its shape depending on the trading rule. For instance, in the simulation of the model with uniform saving factor the stationary distribution of holding time obeys exponential law, while in the model with diverse saving factor the distribution changes to a power type [7].

The transfer rate of money has an inverse relation with the average holding time of money. When the circulation process is in the nature of Poisson one,
the probability distribution of the latency time of money takes the following form [6]

\[ P(t) = \frac{1}{T} e^{-\frac{t}{T}} \]  

(1)

where \(1/T\) corresponds to the intensity of Poisson process, and \(T\) signifies the average holding time of money. In this case, the velocity of money can be written as

\[ V = \frac{1}{T}. \]  

(2)

Since the average holding time is governed by the money holders (agents in the models), the above equation suggests that the velocity is determined by the behavior patterns of economic agents. Employing the well-known life-cycle model in economics, Wang et al. demonstrated that the velocity of money can be obtained from the individual’s optimal choice [13]. Thus the study on the transferring process provides a new insight into the velocity of money circulation.

2.4 Money Creation

With the help of money transfer models, we can still discuss the impact of money creation on the statistical mechanics of money circulation. In reality, most part of the monetary aggregate that circulates in the modern economy is created by debts through banking system. Thus money creation has important influence on the characteristics of monetary economic system.

Recently, some investigations have been carried out in this line mainly from two perspectives. One is from physics perspective. Adrian Drăgulescu and Victor Yakovenko demonstrated the equilibrium probability distribution of money follows the Boltzmann-Gibbs law, allowing agents to go into debt and putting a limit on the maximal debt of an agent [1]. Robert Fischer and Dieter Braun analyzed the process of creation and annihilation of money using a mechanical method and examined how money creation affects statistical mechanics of money [8]. The other is from economics perspective. It is known that the essence of money creation can be represented by the required reserve ratio from the multiplier model of money in economics. Thus we can examine the dependence of monetary wealth distribution and the velocity of money on the required reserve ratio based on a transfer model of money and computer simulations. We extended a money transfer model by introducing a banking system, where money creation is achieved by bank loans and the monetary aggregate is determined by the monetary base and the required reserve ratio. The simulation results show that monetary wealth follows asymmetric Laplace distribution, and the velocity decreases as the required reserve ratio increases. For more details you can see Ref. [14].
3 Discussion and Conclusion

The money transfer models were constructed originally for explaining the real income or wealth distribution. They also can be applied to other economic issues, such as economic mobility, transfer rate and money creation. These applications will bring this kind of models to be rival to the prevailing models in monetary economics. Of course, the current version of these models is far from perfectness. In order to fulfill the goal, some further improvements and modifications are required. One is to make the agents in the model closer to rational economic ones. Another one is to analyze the model in a generalized mathematical way, which would help us to understand the model deeply and completely and show the right way to structural modification.

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