



# The velocity of money in a life-cycle model

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## Abstract

The determinants of the velocity of money have been examined based on life-cycle hypothesis. The velocity of money can be expressed by reciprocal of the average value of holding time that is defined as interval between participating exchanges for one unit of money. This expression indicates that the velocity is governed by behavior patterns of economic agents and opens a way for constructing micro-foundation of it. It is found that time pattern of income and expense for a representative individual can be obtained from a simple version of life-cycle model, and average holding time of money resulted from the individual's optimal choice depends on the expected length of relevant planning periods.

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## 1. Introduction

The topic of money dynamics recently attracted considerable research interest within statistical physics [1–6]. Motivated by the initial work of Vilfredo Pareto in 1897 [7] on distribution of income among people in some countries and some recent empirical observations of econophysicists [8–11], several money transfer models have

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been developed for the equilibrium money distribution based on the analogy between market economics and kinetic theory of gases [1–4,10]. Adrian Drăgulescu and Victor Yakovenko [1] proposed a model of agents exchanging randomly in a closed economy and demonstrated that the equilibrium probability distribution of money follows the exponential Boltzmann–Gibbs law due to time-reversal symmetry and conservation of money. The research group of Chakrabarti [2,3] investigated the statistical mechanics of money, similarly, considering effects of the saving behavior of the agents. Based on these studies of the subject, Wang et al. [12,13] introduced a new aspect of the problem: the probability distribution of money holding times. These works expand the scope of such investigations from focusing on the static distribution of money to discussing the circulation of money.

The velocity of money circulation is a central matter in monetary theory that has attracted much attention for hundreds of years [14]. Although exploration of the velocity can be traced backward to the earlier works in 1660s [15], most of current investigations of velocity is commonly attributed to Irving Fisher who presented an influential exchange equation  $MV = PY$ , where  $M$  is the amount of money in circulation,  $V$  is the velocity of circulation of money,  $P$  is the average price level and  $Y$  is the level of real income [16]. From this equation, the velocity of money can be computed as the ratio of transaction volume or aggregate income to money stock. Based on this equation, many theoretical and empirical research works on the velocity have been carried out to examine its determinants [17–20]. However, the Fisher equation just proposed a definition and a measurement of velocity in any way, it could not uncover the intrinsic properties of the velocity. It resembles Ohm's law, though with the help of the equation  $V = RI$ , resistance  $R$  can be calculated by dividing supplied voltage  $V$  by consequent current  $I$ , it is determined by its internal characteristics, rather than those two variables. Just as Rothbard [21] reminds us, “it is absurd to dignify any quantity with a place in an equation unless it can be defined independently of the other terms in the equation.” Thus, by analogy with resistance, the velocity must have a “life of its own” characterized by the money holders.

The purpose of this paper is to analyze the circulation velocity of money on the base of micro-analysis. In our recent work, the velocity was expressed as a statistical function of holding time of money [12]. This relation provides a novel channel through which the velocity can be determined by individual goal-directed behavior. With the help of the life-cycle hypothesis, an alternative approach without taking any aggregate macro-economic variables into account is presented for examining the monetary velocity.

## 2. Holding time versus velocity of money

To use money, people must hold money. However, what they are holding now must be spent on something on certain moment later, so a given amount of money can be used again and again to finance people's purchases of goods and services. In other words, the money one person spends for goods and services at any given moment can be used later by the recipient of that money to purchase yet other goods

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