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Mobility and volatility: What is behind the rising income inequality in the United States

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HIGHLIGHTS

- This paper helps bridge the gap between econophysics and social sciences.
- We re-define the terms in Fokker–Planck equation as income mobility and volatility.
- Rising volatility is a major contributor to the surge in U.S. income inequality.
- The probability of income growth has become lower for all American households.

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ABSTRACT

Inequality of family incomes in the United States has increased significantly in the past four decades. This is largely interpreted as a result of unequal mobility, e.g., the rich can get richer at a faster pace than the rest of the population. However, using nationally representative data and the Fokker–Planck equation, our study shows that income mobility in the United States has remained stable. Instead, we find another factor – income volatility, which measures the instability of incomes – has increased considerably and caused the surge of income inequality. In addition, the rising volatility is associated with the plummeting of income-growth opportunity, creating the feeling that the American Dream is in decline. Volatility has often been overlooked in previous studies on inequality, partially because mobility and volatility are usually studied separately. By contrast, the Fokker–Planck equation takes both mobility and volatility into consideration, making it a more comprehensive model.

1. Introduction

Since the 1970s, the inequality of household incomes in the United States has increased considerably [1–4]. This trend can be caused by changes in income mobility. For instance, if the affluent can become wealthier at a faster pace, while the growth-rate of the middle class and the poor stays constant, this will lead to the increase of income inequality. Indeed, the income share of the top 1% U.S. households doubled from 1979 to 2007 owning largely to the growth of CEO and executive compensation [5,6]. On the other hand, the surge of inequality can also be a result of rising income volatility [7,8], a measure of the instability of household income. A few studies have found that U.S. household incomes became more volatile during the preceding decades [9–13]. Yet, because these studies focus primarily on detecting the trend of volatility, the causality between volatility and inequality has received limited attention. Moreover, much of the existing research on

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income distribution uses cross-sectional data; these data, however, only provide snapshot information [4,14–17] and reveal little about income volatility. To clarify the impact of mobility and volatility on income disparities, a more comprehensive model that contains both factors is needed.

Regarding income distribution models, Pareto's seminal work [18] has inspired an avalanche of related studies. For example, Champernowne has constructed a stochastic model to simulate Pareto's power law [19], and Mandelbrot has applied Lévy's theory to develop the Pareto-Lévy law [20]. A large portion of recent effort has been spent on constructing new models that are able to replicate the income's cumulative distributions. These include, among others, the κ-generalized distribution [21], kinetic exchange models [22,23], generalized Lotka–Volterra models [24], Boltzmann–Gibbs distribution and Yakovenko models [25–28]. These models are based on intuitive assumptions or phenomenological arguments such as multiplicative and additive randomness [26]. Although the models' prediction exactly matches the empirical data (such as data from the U.S. Internal Revenue Service [28]), the socioeconomic meanings of these models have not been fully explored. As a result, critical socioeconomic concepts such as mobility and volatility are not reflected in these models. This limits the opportunity to apply these models to social sciences and, in particular, makes it difficult for econo-physicists to communicate with social scientists [29]. In this paper, we examine the factors of mobility and volatility embedded in the simplest model—the Fokker–Planck equation-based model [27,28]. Our results show that this equation is more than a match for empirical data; it can provide insightful knowledge about the causal dynamics of economic inequality – especially how income mobility and volatility affect inequality – and can shed light on the decline of the American Dream.

2. Data

To overcome the limitations of cross-sectional data, we carried out a longitudinal study on household income variation using nationally representative data from the Panel Study of Income Dynamics (PSID) [30]. PSID is the world's longest-running household panel survey that has tracked thousands of American families since 1968. The PSID originally included two sub-datasets: a nationally representative sample designed by the Survey Research Center (SRC) at the University of Michigan, and a low-income family sample designed by the Bureau of Census. In this paper, we only used the SRC data since the other dataset was not nationally representative. The SRC data archived, among other things, the employment, income, wealth, and expenditures of members of 2930 households in 1968. As the members of SRC families grew up, moved out, and formed new families, they were interviewed separately as newly established households. These new families were referred to as the "split-offs". By 2013, a total number of 13,776 SRC households had been interviewed. The interviews were conducted annually from 1968 to 1997, and biennially thereafter.

In this paper, the group of families interviewed in 1968 was denoted as *G0*. These family heads' ages ranged from 20 to over 90. Many of the families were well established at the time of their first interviews. In this paper, we focused on split-offs established by the offspring or members of *G0*. We used *Cohort G1* to label those families, formed between 1969 and 1980 with a family head younger than 45 at the time of the first interview. The age was controlled so that the cohort had similar working experiences. Those formed between 1981 and 1990 with a head younger than 45 were *Cohort G2*, and those from 1991 to 2000 were *Cohort G3*. These three cohorts can be regarded as three generations. The average ages of the heads in *G1*, *G2*, and *G3* in 1980, 1990, and 2000 were 36, 37, and 39, respectively. Fig. 1 shows the median and mean incomes of *G1*–*G3* as well as the median of all U.S. household incomes (values not adjusted for inflation). The cohort medians increase at a rate of about \$3200/year and the mean value increments are about \$2400/year.

The total family income, $X(t)$, is the sum of all family members' taxable incomes, transferred money, and social security income. The PSID website has detailed descriptions of these variables. Because PSID did not collect data in the even years after 1997 (e.g., 1998, 2000, 2002, etc.), we chose not to analyze data from the even years before 1997 in order to keep the time step Δt constant, i.e., $\Delta t = 2$ in our computations. This allowed us to compute the income-rise, mobility, and volatility using the same time scale.

3. Definition, model, and method

3.1. Definition of mobility and volatility

Within each cohort, we classify its households into different social classes (i.e. income-based positions on the social ladder) according to their income-to-mean ratio $x(t) = X(t)/M(t)$, where $X(t)$ is the total family income in the year t and $M(t)$ is the mean income of the cohort. Since both $X(t)$ and $M(t)$ contain the same inflation factor, their ratio $x(t)$ is free from the influence of inflation. Due to unexpected events such as illness or unemployment, x (and X) can vary randomly over time. The variation $r(t) = x(t + \Delta t) - x(t)$ indicates the up-and-down of an individual family over Δt years. To investigate the relationship between r and inequality, we define the mobility of a social class as the mean value of r divided by Δt for all families in the class x in the year t. In other words, the mobility of a social class is the average change-of-status per year for all households within that class. The volatility of a social class is defined as the standard deviation of r divided by $2\Delta t$. The mathematical expression of mobility is $F(x) = \int_{-\infty}^{\infty} rA_x(r)dr/\Delta t$, and volatility is $S(x) = \int_{-\infty}^{\infty} [r - mean(r)]^2 A_x(r)dr/2\Delta t$, where $A_x(r)$ is the probability of having an r increment among the x-class families. As discussed later, $A_x(r)$ can also be a function of time t, but we omit the time argument in the above expressions for simplicity. Generally, $F(x) > 0$ (or < 0) means the entire social class tends to move upward (or downward) along the social ladder. Unlike current studies that quantify