



Evolution of consumption distribution and model of wealth distribution in China between 1995 and 2012



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HIGHLIGHTS

- The PDFs ($P_c(x) = K(x - \mu)e^{-\frac{(x-\mu)^2}{2\sigma^2}}$) of consumption appear identical with PDFs of income in China.
- The consumption of majority population is strongly influenced by their income.
- The residue PDFs between 1995 and 2012 are close to a Gaussian distribution.
- Gaussian distribution of residue PDFs derive from high propensity of savings.
- High propensity of savings is attributed to the rapidly increasing payments.

ARTICLE INFO

Article history:

Received 21 August 2014

Received in revised form 13 February 2015

Available online 23 February 2015

Keywords:

Econophysics

Probability density functions

Kinetic wealth-exchange model

ABSTRACT

We study the evolution of the distribution of consumption of individuals in the majority population in China during the period 1995–2012 and find that its probability density functions (PDFs) obey the rule $P_c(x) = K(x - \mu)e^{-\frac{(x-\mu)^2}{2\sigma^2}}$. We also find (i) that the PDFs and the individual income distribution appear to be identical, (ii) that the peaks of the PDFs of the individual consumption distribution are consistently on the low side of the PDFs of the income distribution, and (iii) that the average of the marginal propensity to consume (MPC) is large, $\overline{MPC} = 0.77$, indicating that in the majority population individual consumption is low and strongly dependent on income. The long right tail of the PDFs of consumption indicates that few people in China are participating in the high consumption economy, and that consumption inequality is high. After comparing the PDFs of consumption with the PDFs of income we obtain the PDFs of residual wealth during the period 1995–2012, which exhibit a Gaussian distribution. We use an agent-based kinetic wealth-exchange model (KWEM) to simulate this evolutionary process and find that this Gaussian distribution indicates a strong propensity to save rather than spend. This may be due to an anticipation of such large potential outlays as housing, education, and health care in the context of an inadequate welfare support system.

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1. Introduction

In recent decades, physicists have become increasingly interested in complex economic and social systems. Among these new interdisciplinary efforts is econophysics, a research field first named by Stanley in 1995 that applies the methods of

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statistical physics to problems in economics and finance [1]. By focusing on the quantitative analysis of large amounts of economic and financial data it has produced a large number of dynamic models that have greatly expanded our understanding of the world of economics [2–5].

Economic inequality (including consumption inequality, income inequality, and wealth inequality) is becoming an increasingly important topic in both economics and econophysics [6–12] because it is a strong factor in lowering intergenerational earnings mobility [13] and causing recessions [14]. Using the tools of econophysics to carry out a dynamic analysis of the evolution of consumption, income, and wealth distribution is a challenging project. A recent article [10] presented a study of a huge point-of-scale (POS) dataset from a convenience store chain in Japan that found that the density distribution function (PDF) of the consumption of a person in a single shopping trip follows a power law with an exponent of 2. The estimated Gini coefficient was 0.70, implying extreme economic inequality in consumption. Another article [15] presented a study of the evolution of the consumption distribution in India and proposed a statistical model for the consumption distribution that follows either a double Pareto distribution or a mixture of log-normal and Pareto distributions. Due in part to the fact that income data are more available than consumption data, this distribution of consumption has received significantly less scientific attention than the distribution of income. If we are to have a useful understanding of the economic process, however, a theory describing the relationship between the distribution of income and the distribution of consumption is urgently needed [15]. An econophysics approach using a quantitative analysis of the dynamics of an economic system promises to identify and measure the relevant variables and produce new models.

The economy in China has developed rapidly over the past decade and is attracting an increasing amount of attention among economists and econophysicists [16–22]. This rapid development has produced some negative effects, among which is a dramatic increase in economic inequality. This economic inequality has in turn produced social inequality and its attendant stress on low-income households and workers [23,24]. This disparity between rich and poor in China has been identified as an important factor driving China's rapid economic development. Since the policy of "letting a minority of the population get rich first" was first instituted in China, this competitive factor has been treated as key in the reform of the economic system in China and essential if the shift from a planned economy to a free-market system is to be accomplished.

In a study of the evolution of the distribution of individual annual incomes across the majority population in China during the period 1992–2009 [25], we found that income inequality was growing during that time. In the early years of that period, the PDF of individual incomes is extremely close to a Gaussian distribution. In later years the PDFs widen and a factor $(x - \mu)$ – in which x is a variable of income and μ the average income – progressively skews the curve to the right [25]. An extrapolated long right tail indicates that a minority of the population enjoys an extremely high income (i.e., there is strong economic

inequality) and a modified-Gaussian (MG) model emerges, $(x - \mu)e^{-\frac{(x-\mu)^2}{2\sigma^2}}$ [26]. The $(x - \mu)$ factor causes the right tail to lengthen and the curve to lose its symmetry. Many studies of the evolution of income and wealth in economic systems agree that in nearly all cases the top 1%–5% of a population will eventually acquire most of the wealth, and that this phenomenon is a self-organized behavior [6,7,12,27], the so-called Pareto law [28,29]. Survey data from empirical studies of economic changes in such highly developed countries as the US [30], the UK [31], Germany [32], and Japan [10] also demonstrate this phenomenon. We thus assume that the increasing wealth disparity between the rich and the poor in China is a part of the process of economic development, and that it is both the driver of economic competition and ultimately a cause of social conflict.

Our goal is to determine whether the distribution of consumption in China exhibits this same inequality. We also want to describe the dynamic relationship between the evolution of the distribution of consumption and the evolution of the distribution of wealth. We hope this approach will yield a more complete understanding of the dynamics of economic inequality. Using the tools of econophysics we will examine the relationship between income and consumption—which are closely related variables in the Keynes theory of macroeconomics.

The paper is organized as follows. Section 2 presents the CDFs and PDFs of the consumption distribution in China between 1995 and 2012. Section 3 presents the residual distribution between income and consumption distribution with their fitting curves during the period 1995–2012. Section 4 simulates the evolution of income distribution and consumption distribution and then obtains the final wealth distribution. Section 5 presents our conclusions.

2. The CDFs and PDFs of consumption

We begin by analyzing the survey data of per capita annual consumer expenditure released by the National Bureau of Statistics of China (NBS) (China Statistical Yearbook: <http://www.stats.gov.cn/tjsj/ndsj/>) and study their cumulative distribution functions (CDFs) $C(x) = \int_x^\infty P(x')dx'$. A CDF can be directly constructed from a dataset without making subjective choices (see Fig. 1). The inherent survey data from NBS are sorted into seven ascending levels of consumer expenditure (see Table 1). The lowest and highest quintiles are each divided into two, while the second, third and fourth quintiles are presented as is. We also give the data of income in Table 2 for comparison. Because our main purpose is to investigate the consumption distribution in China between 1995 and 2012, this survey classification significantly weakens the influence of the small populations of extremely low-consumption individuals and extremely high-consumption individuals. These sorted data reflect the egalitarian distribution of Chinese consumption and income 25 years ago when mild deviations occurred only when "work experience" or "great contributions to society" became factors in determining income and consumption. This configuration of consumption and income did not end completely until 2002, when global economic competition became a strong factor due to China's entrance into the WTO.

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