The Memorylessness of the iPhone Index and Its Global Inequality Revelation

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Abstract. Global economic inequality is one of the most important issues across the globe, which has traditionally been measured by macroeconomic indicators like the Gini coefficient, which often lack tangibility. The iPhone Index, which measures the working days required to purchase an iPhone across countries, shows us a compelling and intuitive alternative for assessing disparities in purchasing power. This study investigates whether the 2024 global distribution of this index follows an exponential distribution. The study utilizes datasets on picodi.com in 44 countries, this study employs Maximum Likelihood Estimation (MLE) to fit an exponential model and the Chi-Square goodness-of-fit test to validate it. The results (χ^2=1.75, p=0.416) confirm that the data is consistent with an exponential distribution (λ=0.0505). Furthermore, a comparative analysis between the 2023 and 2024 indices reveals subtle yet meaningful shifts in global inequality patterns. This study concludes that the iPhone Index does not adhere to an exponential distribution but also serves as an accessible and interpretable metric for policymakers and researchers monitoring global technological inequality and its evolution over time.

Keywords: Exponential distribution, social inequality, Chi-Square Test, iPhone Index, Exponential Distribution.

1. Introduction

1.1. Research Background and Topic

Nowadays, global economic inequality remains one of the most pressing challenges, impacting our economic growth and stability. Traditionally, economists and sociologists have relied on macroeconomic indicators such as the Gini coefficient, the Palma ratio, or gross domestic product (GDP) per capita to measure and compare disparities between nations and within populations. These figures consider the income distribution as an indicator to show social inequality, but they do not demonstrate the direct correlation between purchasing power of one product and inequality to capture the concrete reality of inequality.

The Big Mac Index shows that a single well-recognized good across the globe can reflect purchasing power parity in an intuitive way [1]. In addition, the iPhone, a world-famous brand with sales of 232.1 million units in 2024, which releases a new model every year at a similar price point across countries, can effectively reflect social inequality through the comparison of required working days to purchase it in different countries [2].

1.2. Research Purpose and Significance

The research has two significant effects. First, to investigate whether the global distribution of the iPhone Index across nations adheres to an exponential distribution. Besides, if the data follows the distribution, a new way is used to identify global consumption inequality, the study simplifies all sorts of data regarding income to a single interpretable parameter λ. It can be used to monitor trends in technology-driven inequality over time, assess the impact of global economic events, and design more targeted economic policies, providing a useful tool to policymakers, international organizations, and educators.

1.3. Research Methods and Structure

This research employs secondary data from Picodi.com, which collects and shows the average days required for citizens in different countries to buy a new iPhone Pro in 2023 and 2024 [3, 4]. The study utilizes Maximum Likelihood Estimation (MLE) to fit an exponential distribution to the data and determine its parameter. Then, the Chi-Square Test is applied to assess whether the data follows the proposed exponential model. Furthermore, comparative analysis is conducted between the parameters for 2023 and 2024.

Section 2 illustrates other methods to research into economic inequality measurement and the use of exponential distribution in other social issues. Section 3 shows the main methodology of my research, including data sourcing, preprocessing, and the statistical techniques of MLE and Chi-Square testing. Section 4 presents the statistics, hypothesis testing outcomes, and the calculation of the λ parameter. Eventually, Section5 concludes the paper by summarizing the main findings, acknowledging the study's limitations, and suggesting improvement for future research.

2. Literature Review

2.1. Diversified Measurement Methods of Income Inequality

The study of economic inequality originally uses established metrics such as the Gini coefficient and Theil index [5,6]. Gini coefficient ranges from 0 to 1. A coefficient number of 0 represents that everyone in the society share the same amount of income or wealth, whereas the coefficient of 1 represents completely inequality, which means some people owns all wealth while some others have 0; Theil index ranges from 0 to infinity, where o shows perfect equality and a higher value indicates greater inequality with no upper limit.

While these measures provide valuable summaries of income or wealth distribution within and between populations, they often abstract away from the lived experience of inequality. Hence, increasingly people choose to use the "Big Mac Index" [1], which uses a popular consumer good to illustrate purchasing power parity. Building on this concept, the 'iPhone Index' serves as a valuable alternative for measuring consumption-based inequality.

2.2. The Application of Exponential Distribution in Social Community

Exponential distribution is well-known and important in modelling the time between events in a Poisson process, featured by memorylessness which means the probability at any given interval with a same parameter is the same [7]. This property makes it suitable for analysing various socio-economic phenomena where the waiting time for an event is random and uncorrelated over time [8]. It has been successfully applied in reliability engineering to model failure times, in queuing theory for service wait times, and in earth sciences for forecasting the recurrence intervals of earthquakes or floods. In economics and sociology, it has been used to model the duration of unemployment spells or the time until adoption of a new technology. Therefore, the research can put it into application in the field social inequality, particularly in modelling the distribution of acquisition effort for a global luxury good like the iPhone.

3. Methodology

3.1. Data Source and Processing

The dataset for this study is collected from the iPhone Index 2024 report by the website Picodi.com [4]. To make a comparison, the iPhone Index 2023 is utilized report from the same website [3]. The 2024 dataset reports the net number of working days required to purchase the base model iPhone 15 (128GB) across 50 countries. In order to ensure a comparable sample, we only choose to use 44 countries which exist in both datasets. No data points were excluded for any other reason, as the provided data for these 44 countries was complete.

3.2. MLE for Exponential Distribution and Validation via Chi-Square Test

Let $X= (x_1, x_2, \dots, x_n)$ represent the number of working days for *n* countries. The probability density function of the exponential distribution is:

$$f(x, \lambda) = \begin{cases} \lambda e^{-\lambda x}, & x \geq 0 \\ 0, & x < 0 \end{cases} \tag{1}$$

The parameter λ is estimated using MLE [7]. The study creates the likelihood function:

$$L(\lambda) = \prod_{i=1}^{n} f(x_i;\ \lambda) = \lambda^n e^{-\lambda \sum_{i=1}^{n} x_i} \tag{2}$$

The log-likelihood function is simplified to:

$$l(\lambda) = \ln L(\lambda) = n\ln(\lambda) - \lambda \sum_{i=1}^{n} x_i \tag{3}$$

Using the principle of derivatives to maximize this function, the study obtains the MLE estimator:

$$\hat{\lambda} = \frac{1}{\bar{x}}. \tag{4}$$

The core analytical method is the Chi-Square Goodness-of-Fit test, which assesses whether the observed frequency distribution of the data fits a theoretical exponential distribution. The steps involve separating data with same interval into different bins and comparing the observed number of data points in each bin $(O_i)$to the number expected under the exponential distribution hypothesis (E_i). The Chi-Square test statistic is computed as:

$$\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i} \tag{5}$$

A resulting p-value greater than the significance level (α=0.05) fails to reject the null hypothesis (H_0) that the data follows the exponential distribution.

3.3. Comparative Analysis

The study uses the same method to derive λ_{2023} and λ_{2024} and make a comparative analysis between the parameter in year 2023 and 2024. A decrease in λ signifies an increase in the mean number of working days required, thereby indicating a potential worsening of global inequality in terms of iPhone affordability, and vice versa.

4. Result

4.1. Descriptive Statistics and Parameter Estimation

The descriptive statistics for the 2024 sample (n=44) are presented in the Table 1. The mean number of working days required is 19.8 days, and the MLE for the rate parameter λ is calculated as $\lambda_{2024} = \frac{1}{19.8} = 0.0505$.

Table 1. Descriptive Statistics of iPhone Index 2024 (n=44)

Statistic	Value
Sample Size (n)	44
Mean	19.8 days
Minimum	4.0 (Switzerland)
Maximum	72.9（Türkiye）
MLE Estimate	0.0505

4.2. Chi-Square Test Results and Interpretation

To perform the Chi-Square test, the data was separated into 4 intervals (bins) based on the quantiles of the theoretical exponential distribution with λ=0.0505, The results of the test are summarized in Table 2. And the study states the null hypothesis：The data follows an exponential distribution.

Table 2. Chi-Square Test Results for 2024 Data

interval	Observed Freq.		Expected Freq	χ^2
[0,12]	20	F(12)=1-e^(-0.05053*12)≈0.453	19.93	0.00025
[12，20]	11	F(20)-F(12)≈0.637-0.453=0.184	8.1	1.03
[20，30]	6	F(30)-F(20)≈0.782-0.637=0.145	6.38	0.0226
[30,∞]	7	1-F(30)≈1-0.782=0.218	9.59	0.699
				1.75185

The study summarizes the observed frequency in 4 intervals and calculates the theoretical probability with parameter λ, so $\chi^2 = 1.75185$. The degrees of freedom for the test are df=4−1−1=2. The corresponding p-value for $\chi^2 = 1.75185$ with df=2 is 0.416. Since the p-value (0.844) is significantly greater than the common significance level of 0.05, the study fails to reject the null hypothesis: The data follows an exponential distribution. This result provides strong statistical evidence that the global distribution of the iPhone Index for 2024 is consistent with an exponential distribution.

4.3. A comparison between 2023 and 2024

A comparative analysis of the iPhone Index between 2023 and 2024 was conducted on the identical set of 44 countries (Table 3).

Table 3. Chi-Square Test Results for 2023 Data

interval	Observed Freq.		Expected Freq.	χ^2
[0,12]	20	F(12)=1-e^(-0.05053*12)≈0.453	19.93	0.00025
[12，20]	9	F(20)-F(12) = 0.545-0.364=0.181	7.964	0.1347
[20，30]	8	F(30)-F(20)=0.364-0.219=0.145	6.38	0.4114
[30,∞]	7	1-F(30)≈1-0.782=0.218	9.59	0.699
				1.24535

With calculation, the study finds that the iPhone Index for both years passed the Chi-Square goodness-of-fit test (2023: χ^2=1.75, p=0.416; 2024: χ^2=1.25, p=0.536). This big finding validates the statistical structure: the exponential distribution is a useful model in describing global purchasing power of iPhone.

Table 4. Descriptive Statistics of iPhone Index 2023 (n=44)

Statistic	Value
Sample Size (n)	44
Mean	22.19 days
Minimum	4.2 (Switzerland)
Maximum	123.7（Türkiye）
MLE Estimate	0.045

With comparing and contrasting, the study also finds that the ranking of countries remained relatively stable. Türkiye has always been the country that takes the longest time to purchase a mobile phone while United States and Switzerland persistently required.

It is also clear that the key difference lies in the estimated rate parameter (λ). The value increased from 0.045 in 2023 to 0.0505 in 2024. People need to work fewer days to buy a new releases iPhone, however this change originated from the unusually high value of the time required for Turkey to purchase mobile phones in 2023 (123.7) (Table 4). If this outlier is removed, when calculating the average, the required time in 2024 is even longer, signifying a measurable widening of the global consumption inequality gap over the one-year period and a slightly decreasing power of purchasing.

5. Discussion

The core progress in the study is that the global distribution of time to buy a new iPhone satisfies exponential distribution. This mathematical property starkly highlights the persistent and structural nature of global technological inequality. It indicates that the observed inequality is not random but follows a predictable, systemic pattern, and this pattern is difficult to break. There is a very big difference in value of the mean day. The model tells us that while a worker in Switzerland achieves this goal in a mere 4 days, a worker in Türkiye must devote 72.9 days of labor—over 18 times longer. The "memoryless" property means this big difference remains regardless of effort.

Theoretically, this research bridges statistical theory and economic measurement，showing an economic phenomenon by a simple probabilistic distribution. Practically, λ is a single, easily interpretable number that can track changes in global inequality over time. A decrease in λ would signal a worsening of inequality, while an increase would suggest improvement. This can help monitor the impact of global economic events.

The study also shows some limitations. First, the accuracy of the analysis is dependent on the reliability of the underlying data source (Picodi.com) regarding local net salaries and iPhone pricing. It is not clear whether Picodi can get right information in every country. Secondly, the sample, though covering a wide range of economies, is not exhaustive of all countries, which may introduce some bias.

In the future, it is better if more information can be achieved in every country to make more thorough research. Besides, future research should aim to construct a longer time-series dataset to analyse the dynamics of λ over a more extended period, providing more insights into trends. It is also recommended to utilize more types of well-known goods such as electric vehicles to create a deeper relationship between inequality and items.

6. Conclusion

This study demonstrated that the global distribution of working days required to purchase an iPhone follows an exponential distribution, characterized by the memoryless property. The study validated this using MLE and Chi-Square goodness-of-fit tests on data from 44 countries across 2023 and 2024. The exponential distribution model effectively captures the persistent and structural nature of global technological inequality, with parameter λ serving as a concise measure of this inequality.

Our research has limitations related to data reliability and coverage, as it depends on secondary sources and doesn't include all countries. The analysis may also be affected by outliers, such as the extreme value observed for Türkiye in 2023.

Future research should expand data collection to include more countries and longer time periods. Investigating other consumer goods using similar methodology would help build a more comprehensive understanding of global consumption inequality. Additionally, exploring the relationship between λ and macroeconomic indicators could provide insights into the drivers of technological inequality across nations.

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