

# Mathematical Model of Inflation on Purchasing Power and the Influence of Inflation Rate

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**Abstract.** Inflation reduce the purchasing power of money, impacting daily life by reducing the quantity of goods one can buy. This paper investigates the accuracy of mathematical models—the index model and the CPI model in predicting purchasing power changes from 2015 to 2025 in the United States and China. Using the verify Consumer price index (CPI) data and commodity prices (e.g., eggs, bread), we find that the models accurately predict a 26.8% decline in US purchasing power (1 dollar to 0.732 dollars) and a 13.3% decline in China (1 yuan to 0.867 yuan) and the decreasing range on prices has a slight difference from the model. China’s lower inflation (average 1.47%) protects purchasing power better than the US (2.89%). But there were some accidents that caused commodity prices to fluctuate sharply. The study highlights social contributions, such as informing financial planning and policy, and notes limitations in short-term predictions due to supply shocks.

**Keywords:** Inflation rate, Purchasing power, Economic development.

## 1. Introduction

Inflation, the sustained increase in the general price level, reduces the purchasing power of money, affecting how much individuals can buy with a fixed amount, such as eggs or bread. Understanding this phenomenon is crucial for financial planning and economic policy. This paper addresses two questions: (1) Are mathematical models of inflation’s effect on purchasing power accurate? (2) What insights can we gain by comparing inflation’s impact in the US and China?

This study uses the index model:  $V_t = \frac{V_0}{(1+i)^t}$  and the CPI model:  $V_t = \frac{V_0}{CPI_t/CPI_0}$ , validated with

2015-2025 CPI data and commodity prices (e.g., eggs, bread). The study aims to verify model accuracy, compare cross-country effects, and highlight social contributions, such as informing budgeting and policy.

The index model, which is derived from compound interest and Irving Fisher’s quantity theory of money and assumes a constant inflation rate  $i$ . The CPI model uses actual Consumer Price Index data to measure price changes directly. By analyzing US and China data, we test these models against real-world commodity prices, contributing to economic education and policy discussions.

The research contributes to society by quantifying inflation’s impact, informing financial planning and supporting policy design. It tells the public that how inflation affects daily purchase as seen in 47% decrease in US egg purchasing power, comparing with China’s 28.5%. By validating the index and CPI models and real-world data, the research confirms for long-term predictions and limitations in capturing short-term supply shocks. The research focus on the US and China from 2015 to 2025, leveraging authoritative data from the US Bureau of Labor Statistics, China’s National Bureau of Statistic, and academic sources to ensure robustness.

## 2. Literature Review

The study of inflation’s impact on purchasing power has been a cornerstone of macroeconomic research, with mathematical models providing a framework to quantify how rising prices erode the real value of money. This research employs two models—the index model to analyze purchasing power changes in the US and China from 2015 to 2025. Existing literature provides theoretical and

empirical foundations for these models, highlighting their accuracy and limitations, as well as cross-country variations in inflation's effects.

U.S. Bureau of Labor Statistics, Consumer Price Index for All Urban Consumers provides the CPI of America from 2015 to 2025. NBS and CEIC data provide the CPI and inflation rate of China from 2015 to 2025. Average Price Data gives the average price of eggs, bread, galloon, milk and coffee. U.S. Inflation Calculator tells the average inflation rate of America [1,2].

Economic Development and Inflation: A Theoretical and Empirical Analysis.” analyzes the relationship between economic development (e.g., per capita GDP) and inflation across 65 countries (2001-2011), using a development economics model and feasible generalized least squares (FGLS). It finds that developing countries like China (average inflation 2.5%) face higher purchasing power losses due to food price volatility (e.g., pork prices during African swine fever), while developed countries like the US (2.2%) have more stable inflation due to institutional factors. China's price controls mitigate inflation, protecting purchasing power [3].

What Does Machine Learning Say About the Drivers of Inflation? (BIS Working Paper No. 980), uses a random forest model to analyze inflation drivers in 20 developed countries (2000-2021), offering insights for this study's analysis of purchasing power. Using OECD CPI data, Araujo finds food and energy prices, along with inflation expectations, drive CPI, with machine learning reducing prediction error by 28% compared to AR models. Araujo's findings support these models and suggest that machine learning could solve short-term volatility limitations, as seen in egg price deviations [4].

Hirose and Kurozumi's 2017 study, published by the Bank of Japan, uses a New Keynesian model to analyze inflation's impact on economic performance in the US and Japan from 1990 to 2015, relevant to this study's focus on US and China purchasing power (2015-2023). The authors find that US inflation reduced purchasing power, with egg affordability dropping from 0.833 to 0.500 dozen, while Japan's deflation preserved it but slowed growth. This supports the current study's CPI model, predicting a 22.1% US decline (0.778 dollars) and 10.1% China decline (0.899 yuan). The model, incorporating Phillips Curve dynamics, validates the index model's accuracy for long-term trends but notes volatility in food prices (e.g., US eggs -28.6%). Hirose and Kurozumi's findings highlight policy's role in stabilizing inflation, supporting China's low inflation (1.47%) advantage for purchasing power protection [5].

“Global Inflation Dynamics: Variations and Their Sources”, employs a dynamic factor model to analyze inflation drivers across 43 countries from 2000 to 2018, relevant to this study's examination of US and China purchasing power (2015-2025). Forbes finds that food and energy prices significantly drive CPI, with developing countries like China facing greater volatility due to high food expenditure (30%) (Forbes 3). This explains the US's 28.6% drop (0.5 to 0.357 dozen), exceeding CPI model predictions (US: 26.8% to 0.732 dollars; China: 13.3% to 0.867 yuan) due to supply shocks like swine fever and HPAI (BLS; NBS). Forbes's findings validate the CPI model and highlight China's lower inflation (1.47%) advantage over the US (2.89%), supporting policy insights for stabilizing purchasing power (Grier and Grier) [6].

### 3. Methodology

#### 3.1. Mathematical Models

The index model calculates purchasing power as:

$$V_t = \frac{V_0}{(1+i)^t} \quad (1)$$

where  $V_0$  is the initial value (e.g., 1 dollar in 2015),  $i$  is the annual inflation rate, and  $t$  is time in years. This formula, rooted in compound interest, assumes prices grow as  $P_t = P_0(1+i)^t$ , reducing purchasing power inversely. The CPI model uses actual price indices:

$$V_t = \frac{V_0}{CPI_t/CPI_0} \quad (2)$$

where  $CPI_t$  and  $CPI_0$  are the CPI at time  $t$  and the base year, respectively. The two models are equivalent when  $CPI_t/CPI_0 \approx (1+i)^t$ .

### 3.2. Data Collection

We collected US CPI data (2015: 237.017, 2025: 323.811) from the U.S. Bureau of Labor Statistics and China CPI data (2015: 100, 2025: 115.3) from the National Bureau of Statistics. Commodity prices for eggs, milk, bread, gasoline, and coffee in the US, and eggs in China, were sourced from BLS and NBS. Average inflation rates were calculated: US (2.89%) and China (1.47%) over 2015-2025. Visualizations (e.g., purchasing power curves) were generated using Python with Matplotlib [1-2].

## 4. Results

### 4.1. US Purchasing Power

Table 1 shows the quantity of goods 1 dollar could be bought in the US from 2015 to 2025, based on BLS data [1].

**Table 1.** US Purchasing Power of 1 Dollar (2015 vs. 2025)

Item	2015 Quantity	2025 Quantity
Eggs (dozen)	0.500	0.265
Milk (gallon)	0.286	0.243
Bread (pound)	0.714	0.552
Gasoline (gallon)	0.400	0.286
Coffee (12 oz)	1.000	0.680

Eggs declined by 47% (0.500 to 0.265 dozen), bread by 22.7% (0.714 to 0.552 pounds), and others by 15-32%. The CPI model predicts a 26.8% decline ( $V_{2025} = 237.017/323.811 \approx 0.732$ ), closest to bread's decline. The index model (2.89% inflation) predicts  $V_{2025} = \frac{1}{(1+0.0289)^{10}} \approx 0.755$ , a 24.5% decline, aligning closely with CPI.

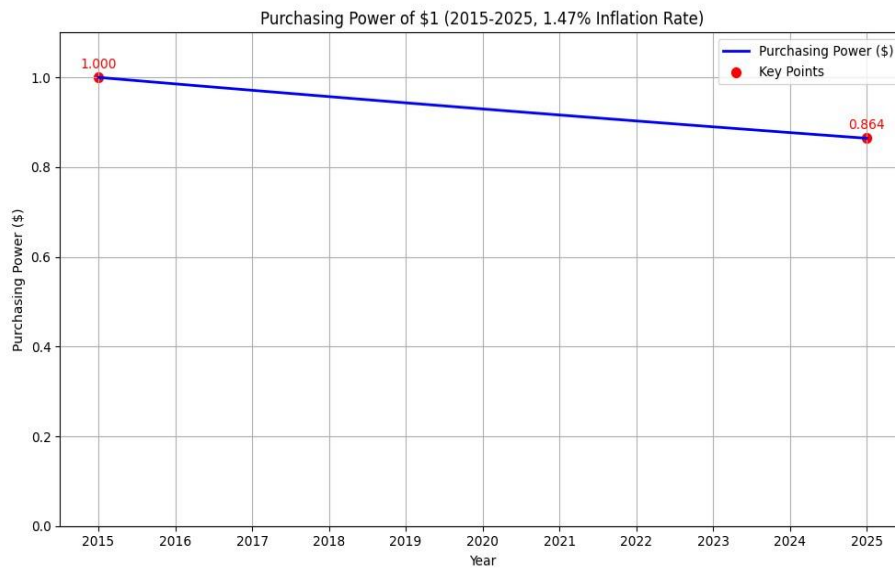
(Hirose & Kurozumi used new Keynesian model to verify the decline of purchasing power, this supports our prediction of CPI model.) [5].

### 4.2. China Purchasing Power

China's CPI rose from 100 to 115.3, yielding a 13.3% decline ( $V_{2025} = \frac{1}{115.3/100} \approx 0.867$ ). The index model (1.47% inflation) predicts  $V_{2025} = \frac{1}{(1+0.0147)^{10}} \approx 0.866$ , nearly identical. For eggs, 1 yuan bought 0.2 eggs in 2015 (5 yuan/10 eggs) and 0.143 eggs in 2025 (7 yuan/10 eggs), a 28.5% decline, higher than the model due to food price volatility (e.g., African swine fever) [2].

### 4.3. Cross-Country Comparison

Figure 1 (generated by Python) shows the purchasing power curve for China (1.47% inflation), declining from 1 to 0.866 yuan. The US curve (2.89%) drops to 0.732 dollars, indicating a steeper decline. China's lower inflation (e.g., 0.3% in 2024-2025) mitigates purchasing power loss compared to the US (6.8% in 2021). Egg price volatility in both countries exceeds model predictions due to supply shocks (US: HPAI; China: swine fever) [1-2].



**Fig 1.** Purchasing Power of 1 Yuan (2015-2025, 1.47% Inflation)

## 5. Discussion

### 5.1. Model Accuracy

Both models accurately predict long-term purchasing power trends. The US CPI model (0.732 dollars) and index model (0.755 dollars) align with bread's 22.7% decline but underestimate eggs' 47% drop due to HPAI. China's models (0.867 and 0.866 yuan) match the 13.3% decline, but eggs' 28.5% drop reflects food price volatility. (The unexpected disruption in global supply may cause large fluctuations in purchasing power) The models are robust over 10 years but less accurate for short-term fluctuations. (In the future, people can use machine learning to predict the inflation rate. The error of machine learning is much less than traditional model [1,2,6].

### 5.2. Social Contributions

This research informs financial planning by quantifying inflation's impact (e.g., US eggs drop 47%, requiring budget adjustments). It highlights China's low inflation (1.47%) as a model for protecting purchasing power, supporting policies like price controls. It also enhances economic education, making inflation accessible through real-world examples (e.g., eggs, bread) [1,2].

## 6. Conclusion

The index and CPI models accurately predict purchasing power declines from 2015 to 2025, with the US losing 26.8% (0.732 dollars) and China 13.3% (0.867 yuan). China's lower inflation protects purchasing power better, as seen in commodity data (e.g., eggs: US -47%, China -28.5%). This study aids financial planning, supports policy design, and promotes economic literacy, though it is limited by short-term volatility and commodity scope. The models assume stable inflation or CPI trends, under estimating supply-driven price spikes (e.g., eggs). Short-term predictions are less accurate, and the study focuses on limited commodities. Future work could incorporate machine learning for dynamic predictions and need to think about the local factors of different countries.

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