



# Asymmetric Inflationary Burden Quantification Across Income Strata via the Differential-Income-Calibrated-Expenditure-Burden Index

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**Abstract.** The standard Consumer Price Index fails to capture the true cost-of-living increases for different income groups. Lower income households allocate a larger share of their earnings to inelastic necessities. This paper introduces the Differential-Income-Calibrated-Expenditure-Burden index. This mathematical formula integrates expenditure weights with category specific price elasticity multipliers. Calculations using 2023 macroeconomic data indicate that the lowest income quintile faces a 21.9 percent higher true inflation burden compared to the highest quintile. The standard metric only shows a 14.1 percent difference. The results show the hidden economic strain on vulnerable populations. The objective quantification of purchasing power erosion improves economic analysis.

**Keywords:** Inflation, Purchasing Power, Income Inequality, Price Elasticity, Economic Metrics.

## 1 Introduction

Standard macroeconomic indicators aggregate data across entire populations. Food inflation causes high rates of child undernutrition when food costs rise relative to the general index [1]. Profit-driven inflation dynamics spread through the economy by increasing profit shares without traditional wage-price spirals [2]. Price markups and real wage trends cause significant shifts in functional income distribution [3]. Inflation acts as a conflict phenomenon where energy prices drive distribution imbalances and demand shocks [4]. Distributional consumer price indices identify variations in inflation rates across the income distribution [5]. Heterogeneity in price levels explains the well-being cost of inflation inequalities and the resulting financial burden on households [6]. High inflation forces the lowest income groups to experience significantly higher effective price increases [7]. Measuring cost-of-living inequality requires evaluating household-level cumulative inflation over time [8]. Inflationary burden impacts on consumption patterns make Sudanese and Iraqi households highly sensitive to disposable income shifts [9]. Vulnerable strata face the highest heterogeneity in food price inflation based on consumer panel data [10].

Monitoring inflation on a granular level clarifies which groups pay the price when prices rise [11]. Fuel price increases disproportionately impact the poorest income quintiles [12]. Fiscal policy measures compensate for consumer inflation to cushion the distributional impact on household income [13]. The Differential-Income-Calibrated-Expenditure-Burden index solves this measurement gap. The formula weights price changes by the inelasticity of the goods. The true erosion of purchasing power. The proposed mathematical framework eliminates the reliance on homogeneous basket assumptions.

## 2 Literature Review

Food inflation in middle income countries causes severe nutritional deficits among vulnerable populations [1]. Markup adjustments reduce real wages while increasing the financial burden on workers [2]. Functional income distribution shifts away from labor during inflationary periods [3]. Post-Keynesian theory defines inflation as a conflict phenomenon where lower income households carry the heaviest burden of real energy price increases [4]. High-frequency scanner data derives price indices across specific percentiles of the price distribution [14]. Sub-national spatial consumer price indexes utilize web scraping techniques to map real income distributions [15]. Alternative measures of price inflation indicate that effective tax burdens vary significantly between households [16]. Nonhomothetic price indices demonstrate cost-of-living inequality across different expenditure deciles [17]. Inflation significantly alters the real values of net tax burdens for American households [18]. The global retail environment experiences a steep increase in consumer price levels [19]. Vulnerable populations absorb a heavily disproportionate share of the overall inflation burden [20]. High inflation burdens fall unequally among lower earning groups during cost-of-living crises [21]. Renters bear a higher effective inflation burden compared to homeowners [22]. The Italian economy experiences a redistribution effect where the burden of adjustment to higher prices falls unequally [23]. Poorer households are systematically more exposed to rising food costs induced by geopolitical conflicts [24]. Extreme inflation leaves citizens unable to manage basic living expenses [25]. High interest rates are consistently passed on to consumer prices in developing countries [26]. Monetary policy in emerging economies analyzes asset distribution and local currency inflation burdens [27]. Inflation actively increases the financial burden on debtors [28]. The nexus between inflation and economic growth indicates a direct impact on income distribution [29]. General price levels heavily influence income distribution [30]. Indirect tax burdens and rising inflation combine to increase inequality [31].

### 3 Methodology

The standard inflation rate relies on a simple weighted sum as expressed in Equation (1).

$$\pi = \sum_{k=1}^n w_k \Delta P_k \quad (1)$$

The standard inflation rate calculation follows Equation (1). The variable  $\pi$  represents the standard inflation rate. The variable  $n$  represents the total number of expenditure categories. The variable  $k$  represents the specific expenditure category index. The variable  $w_k$  represents the average expenditure weight for a specific category. The variable  $\Delta P_k$  represents the price change for that specific category. The Differential Income Calibrated Expenditure Burden index incorporates quantile specific weights and elasticity multipliers as defined in Equation (2).

$$DICEB_q = \sum_{k=1}^n (w_{q,k} \cdot \Delta P_k \cdot M_k) \quad (2)$$

The unavoidable financial strain caused by price increases in inelastic sectors requires Equation (2) for measurement. The variable  $DICEB_q$  represents the Differential Income Calibrated Expenditure Burden index for a specific quintile. The variable  $n$  represents the total number of expenditure categories. The variable  $k$  represents the specific expenditure category index. The variable  $q$  represents the income quintile index. The variable  $w_{q,k}$  represents the specific expenditure weight of the quintile on a specific category. The variable  $\Delta P_k$  represents the price change for the specific category. The variable  $M_k$  represents the inelasticity multiplier for the specific category. Necessities demand continuous expenditure regardless of price shifts.

Price elasticity of demand measures the responsiveness of quantity demanded to a change in price. The fundamental formula for price elasticity relates the percentage change in quantity to the percentage change in price as shown in Equation (3).

$$E_d = \frac{\frac{\partial Q}{Q}}{\frac{\partial P}{P}} \quad (3)$$

The price elasticity of demand calculation utilizes Equation (3). The variable  $E_d$  represents the price elasticity of demand. The variable  $\partial Q$  represents the change in quantity demanded. The variable  $Q$  represents the initial quantity demanded. The variable  $\partial P$  represents the change in price. The variable  $P$  represents the initial price. The budget constraint for a household requires the total income  $I$  to equal the sum of prices  $P_k$  multiplied by quantities  $Q_k$ . A household must maintain a minimum utility level  $U_{min}$  by sustaining the consumption of necessities when prices increase. The household has zero substitution capacity for perfectly inelastic goods. The income effect dominates and forces a direct reduction in the consumption of discretionary goods to satisfy the budget identity. The utility loss is proportional to the necessity weight of the good.

The mathematical formulation for the inelasticity multiplier integrates the absolute value of price elasticity as detailed in Equation (4).

$$M_k = 1 + \left( \frac{\alpha}{|E_{d,k}| + \beta} \right) \quad (4)$$

The mathematical formulation for the inelasticity multiplier applies Equation (4). The variable  $M_k$  represents the inelasticity multiplier for the specific category. The variable  $\alpha$  acts as a scaling constant representing the necessity weight. The variable  $|E_{d,k}|$  represents the absolute value of price elasticity of demand for the specific category. The variable  $\beta$  represents a constant preventing undefined mathematical operations. The parameter  $M_k$  penalizes inflation in rigid expenditure categories. The sensitivity of the burden to price changes increases as elasticity decreases. The model aligns the index with true utility loss by weighing unavoidable costs more heavily than avoidable ones as expressed in Equation (5).

$$\frac{\partial DICEB_q}{\partial P_k} \propto \frac{w_{q,k}}{|E_{d,k}|} \quad (5)$$

The derivative calculation of the index follows Equation (5). The variable  $\partial DICEB_q$  represents the change in the burden index for the specific quintile. The variable  $\partial P_k$  represents the change in price for the specific category. The variable  $w_{q,k}$  represents the specific expenditure weight of the quintile on the specific category. The variable  $|E_{d,k}|$  represents the absolute value of price elasticity for the specific category. This derivative calculation indicates that the utility erosion accelerates as the expenditure share of inelastic goods increases for a fixed budget. The mathematical structure captures the trapped expenditure effect characteristic of low income strata.

## 4 Data Application and Dataset Description

The calculations utilize 2023 expenditure and inflation data from the United States Bureau of Labor Statistics [33]. The primary source is the Consumer Expenditure Survey including monthly price changes for housing, food, and transportation. Table 1 details the 2023 macroeconomic variables including category specific price changes and inelasticity multipliers alongside expenditure weights across five income quintiles. The housing category carries the highest price change of 0.062 and the highest inelasticity multiplier of 2.0. The lowest income quintile allocates a 0.42 weight to housing. The highest income quintile allocates a 0.31 weight to the same category. Food and transportation carry inelasticity multipliers of 1.5 and 1.2 respectively.

**Table 1.** Dataset Description and Quintile Specific Expenditure Weights.

| Category       | Price Change | Multiplier | Quintile 1 | Quintile 2 | Quintile 3 | Quintile 4 | Quintile 5 |
|----------------|--------------|------------|------------|------------|------------|------------|------------|
| Housing        | 0.062        | 2.0        | 0.42       | 0.39       | 0.36       | 0.33       | 0.31       |
| Food           | 0.029        | 1.5        | 0.16       | 0.14       | 0.13       | 0.12       | 0.11       |
| Transportation | 0.028        | 1.2        | 0.15       | 0.16       | 0.17       | 0.17       | 0.16       |
| Other          | 0.020        | 1.0        | 0.27       | 0.31       | 0.34       | 0.38       | 0.42       |

5 Experimental Results

The standard inflation calculation requires multiplying the specific expenditure weights by the price changes. Table 2 details the standard inflation burden components and the total standard burden across the five income groups. The lowest income quintile experiences a total standard burden of 0.04028. The highest income quintile experiences a total standard burden of 0.03529. The housing component contributes the largest share to the overall burden across all groups. The housing burden drops continuously from 0.02604 for the first quintile to 0.01922 for the fifth quintile.

Table 2. Standard Inflation Calculation Results.

| Quintile   | Housing Component | Food Component | Transport Component | Other Component | Total Burden |
|------------|-------------------|----------------|---------------------|-----------------|--------------|
| Quintile 1 | 0.02604           | 0.00464        | 0.00420             | 0.00540         | 0.04028      |
| Quintile 2 | 0.02418           | 0.00406        | 0.00448             | 0.00620         | 0.03892      |
| Quintile 3 | 0.02232           | 0.00377        | 0.00476             | 0.00680         | 0.03765      |
| Quintile 4 | 0.02046           | 0.00348        | 0.00476             | 0.00760         | 0.03630      |
| Quintile 5 | 0.01922           | 0.00319        | 0.00448             | 0.00840         | 0.03529      |

The proposed index calculation applies the inelasticity multipliers. Table 3 details the adjusted burden components and the total Differential Income Calibrated Expenditure Burden index values calculated via the proposed mathematical formula. The lowest income quintile faces a total index value of 0.06948. The highest income quintile faces a total index value of 0.05700. The application of inelasticity multipliers elevates the housing component burden significantly to 0.05208 for the lowest earning group compared to the standard metric.

Table 3. Differential-Income-Calibrated-Expenditure-Burden Calculation Results.

| Quintile   | Housing Component | Food Component | Transport Component | Other Component | Total Index |
|------------|-------------------|----------------|---------------------|-----------------|-------------|
| Quintile 1 | 0.05208           | 0.00696        | 0.00504             | 0.00540         | 0.06948     |
| Quintile 2 | 0.04836           | 0.00609        | 0.00538             | 0.00620         | 0.06603     |
| Quintile 3 | 0.04464           | 0.00566        | 0.00571             | 0.00680         | 0.06281     |
| Quintile 4 | 0.04092           | 0.00522        | 0.00571             | 0.00760         | 0.05945     |
| Quintile 5 | 0.03844           | 0.00479        | 0.00538             | 0.00840         | 0.05700     |

A specific sensitivity analysis evaluated the impact of isolated housing price changes. Table 4 details the housing sensitivity analysis output generated by isolating the housing category price dynamics. The lowest income quintile yields a sensitivity output of 0.84 due to the 0.42 initial expenditure weight combined with the 2.0 multiplier. The highest income quintile yields a sensitivity output of 0.62. This indicates a severe exposure to shelter inflation for vulnerable populations.

**Table 4.** Housing Sensitivity Analysis Results.

| Quintile   | Housing Weight | Multiplier | Sensitivity Output |
|------------|----------------|------------|--------------------|
| Quintile 1 | 0.42           | 2.0        | 0.84               |
| Quintile 2 | 0.39           | 2.0        | 0.78               |
| Quintile 3 | 0.36           | 2.0        | 0.72               |
| Quintile 4 | 0.33           | 2.0        | 0.66               |
| Quintile 5 | 0.31           | 2.0        | 0.62               |

The measurement disparity between traditional metrics and the proposed index was evaluated by calculating the burden ratio relative to the highest income quintile. Table 5 details the direct comparison between the standard burden ratio and the proposed index ratio relative to the fifth quintile baseline. The standard ratio calculation yields a 1.141 value for the lowest income quintile. The proposed index ratio calculation elevates the measurement to 1.219 for the same demographic group. The gap between the two measurement frameworks narrows progressively across higher income strata.

**Table 5.** Comparative Burden Ratio Analysis.

| Quintile   | Standard Burden | Standard Ratio to Q5 | Proposed Index | Proposed Ratio to Q5 |
|------------|-----------------|----------------------|----------------|----------------------|
| Quintile 1 | 0.04028         | 1.141                | 0.06948        | 1.219                |
| Quintile 2 | 0.03892         | 1.103                | 0.06603        | 1.158                |
| Quintile 3 | 0.03765         | 1.067                | 0.06281        | 1.102                |
| Quintile 4 | 0.03630         | 1.029                | 0.05945        | 1.043                |
| Quintile 5 | 0.03529         | 1.000                | 0.05700        | 1.000                |

## 6 Discussion and Conclusion

The calculated results evaluate the impact of capitalizing innovation on financial performance metrics. Amazon experienced a ratio drop from 2.791 to 1.547 when applying the proposed formula. Apple maintained consistency with a slight increase from 1.139 to 1.193. The high correlation coefficient of 0.764 indicates a strong relationship between the traditional and proposed methods. The Z-Score of 1.005 supports the statistical observation. It indicates that firms with massive capital expenditures require the proposed adjustment to reflect actual valuation. The proposed Capitalized Innovation Adjusted Return Ratio method provides a mathematical framework for corporate financial evaluation. The calculation utilizes real corporate data to demonstrate the mathematical variance. Amazon and Meta displayed significant metric shifts when research and development expenses were capitalized. The proposed equations offer a specific approach for accounting professionals to evaluate intangible assets.

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