ACI Research Paper #12-2025

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August 2025

Please cite this article as:

Liang, Zixuan and Wee Yang Ng, "Forecasting 2025 Cost of Living Indices for Expatriates and Ordinary Residents Using Time-Series Approaches", Research Paper #12-2025, *Asia Competitiveness Institute Research Paper Series (August 2025)*

Forecasting 2025 Cost of Living Indices for Expatriates and Ordinary Residents Using Time-Series Approaches

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August 22, 2025

Abstract

Amid heightened global uncertainty, accurate forecasting of the cost of living has become increasingly important. This study applies autoregressive integrated moving average (ARIMA), seasonal ARIMA (SARIMA), and Holt–Winters exponential smoothing models to forecast the consumer price index, category-level inflation, and item prices in the ACI consumption basket for 2025 across 45 major cities. The forecasts indicate relative stability in cost-of-living rankings for both expatriates and ordinary residents, with developed economies consistently occupying the upper tiers. However, substantial variance in the indices highlights widening regional disparities. More importantly, expatriate living costs are more strongly shaped by inflation dynamics and exchange rate fluctuations, with housing prices, transportation costs, and international school fees emerging as the primary drivers.

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1 Introduction

Global cost-of-living dynamics have entered a period of heightened volatility. Since the COVID-19 pandemic, economies have experienced a sharp rise in the cost of living, driven by supply-chain disruptions and the post-pandemic economic recovery (Helper and Soltas, 2021; McGillivray, 2021; Ng and Xie, 2024). Although inflation moderated in many regions by late 2024, the re-emergence of trade protectionism—most notably the broad tariffs announced by the United States in early 2025 [1]—has reintroduced uncertainty into global price movements. These shocks affect not only macroeconomic stability but also the everyday costs faced by households and international assignees.

Accurate forecasting of consumer prices and cost-of-living indices is thus of growing importance since businesses and households can use forward-looking benchmarks to plan wages, compensation packages, and consumption decisions. Yet existing cost-of-living indices, such as those published by the Economist Intelligence Unit (EIU) and Mercer, often provide limited methodological transparency.[2] Moreover, these commercial providers tend to focus narrowly on expatriates, overlooking ordinary residents whose consumption patterns differ significantly.

This paper addresses these gaps by applying autoregressive integrated moving average (ARIMA), seasonal ARIMA (SARIMA), and Holt–Winters exponential smoothing models to forecast the 2025 cost-of-living indices and rankings for expatriates and ordinary residents across 45 major cities in Asia, Australasia, Europe, and North America. The consumer price index (CPI), which depicts changes in the price of a representative basket of goods and services, serves as the basis for tracking the evolution of living costs. Hence, the three forecasting models are applied to predict category-specific CPIs using historical data obtained from the International Monetary Fund (IMF) and national statistical agencies. Performance

[1] On April 2, 2025, President Trump announced "reciprocal tariffs" on imports from all countries not subject to separate sanctions under the International Emergency Economic Powers Act (IEEPA). A universal 10% tariff took effect on April 5.

[2] The Economist Intelligence Unit (EIU) has discontinued its Cost of Living Survey for 2025 and beyond.

metrics —root mean square error (RMSE) and R-squared —are employed to evaluate forecast accuracy, with the best-performing model selected for each category in each country. Finally, category-level inflation rates derived from the CPIs are mapped to all goods and services in the Asia Competitiveness Institute (ACI) consumption basket to estimate item-level prices.

The results suggest that while all models are capable of accurately forecasting the CPIs, the best-performing specification varies across countries and categories. These forecasts provide a useful basis for refining inflation rate calculations. Overall, global inflation is projected to decline in 2025. Most countries are expected to experience a faster-than-anticipated reduction, reflecting easing price pressures, though inflation in several emerging markets and developing economies is likely to remain persistently high.

The forecasts suggest a relative stability in cost-of-living rankings for both expatriates and ordinary residents. For expatriates, the most expensive cities are largely concentrated in North America and Western Europe, with Singapore and Hong Kong standing out as notable exceptions. By contrast, the least expensive cities are predominantly distributed in Southeast Asia. For ordinary residents, cities in developed economies consistently occupy the upper tiers of the rankings, while those in developing economies remain clustered at the lower end. Although only minor shifts in rankings are observed, the significant variance in indices underscores widening regional disparities, suggesting that leading cities are becoming increasingly unaffordable. More importantly, expatriate living costs, by comparison, are more directly influenced by global inflation dynamics and exchange rate fluctuations, with housing prices, transportation expenses, and international school fees serving as the primary cost drivers.

The remainder of the paper is organised as follows: Section 2 examines the data sources and methodology, and Section 3 reports the forecasted inflation and cost of living indices and rankings, while Section 4 discusses the main results. Finally, Section 5 concludes the paper.

2 Methodology

The consumer price index (CPI), which reflects the average change in the prices of a basket of goods and services purchased by households, is a widely used macroeconomic indicator for measuring inflation. Hence, inflation rates derived from predicted CPIs can be used to forecast the prices of goods and services and to project cost-of-living indices.

2.1 Data Sources

The consumption basket proposed by ACI comprises 10 categories.[3] Price data are mainly obtained from the EIU CityData database, which provides annual prices from 2005 to 2024. For the *Miscellaneous Goods and Services* category, price data are obtained from the services category in the UBS Prices and Earnings Study. In total, there are 283 price entries covering 165 goods and services across 45 major cities.[4][5] When multiple prices are reported for a single item across different sales locations, we compute the average prices collected from two different locations, namely a supermarket and a mid-priced store.

Item weights for expatriates reflect their tendency to purchase high-end products aligned with Western consumption preferences. In contrast, ordinary residents follow country-specific weights shaped by geographical location, social values, and cultural affiliations. Item weights are derived from the World Bank's ICP survey, EIU CityData and household expenditure surveys from various countries (Lee et al., 2020).[6]

CPI data are primarily sourced from the International Monetary Fund (IMF) database, which provides quarterly CPI data by category for most countries of interest.[7] For economies

[3]Specifically, the Consumption Categories are: (1) *Food and Non-Alcoholic Beverages*; (2) *Alcohol and Tobacco*; (3) *Clothing and Footwear*; (4) *Housing Rents and Utilities*; (5) *Household Supplies and Domestic Help*; (6) *Health*; (7) *Transport*; (8) *Recreation*; (9) *Education*; (10) *Miscellaneous Goods and Services*.

[4]Since competitiveness research on sub-national economies in Asia is one of the key pillars in ACI, the selection includes all major cities in Asian countries as well as historically high-ranking global cities such as New York, Los Angeles, and Zurich.

[5]Ng and Xie (2025) provides the the complete list of items included under the consumption categories and treatment of items with missing price data.

[6]Following the methodology outlined by Lee et al. (2020) for deriving weights, we can establish a unique set of weights for items under ACI Consumption Category in 2025.

[7]Based on selected cities, the countries for which category-level CPI data are available from the IMF

where category-level CPIs are not available from the IMF — namely China, Hong Kong, India, Indonesia, Japan, the Philippines, and Taiwan — quarterly CPIs are collected and computed from the National Bureau of Statistics of China, Census and Statistics Department of Hong Kong (SAR), Ministry of Statistics & Programme Implementation of India, BPS-Statistics Indonesia, Statistics Bureau of Japan, Philippine Statistics Authority, and National Statistics of Taiwan, respectively. Our CPI forecasting exercise chooses a sample period from Q1 2005 to Q1 2025, comprising 80 observations. Table A.2 in Appendix A provides details on category classification across different data sources.

All price data reported in local currency are converted to US dollars to facilitate international comparison. We collect annual average exchange rates of all cities in the study from the Bank for International Settlements (BIS). All exchange rates are reported in terms of local currency units per USD.

2.2 Data Processing

Heteroscedasticity and non-stationarity are common issues in time series data, especially in macroeconomic indicators such as stock prices and the CPIs. In regression models, it is typically assumed that the variance of the error terms remains constant across all levels of the independent variables (homoscedasticity). However, this assumption may be violated (heteroscedasticity) as data exhibit increasing volatility with the level of the series. Logarithmic transformation can mitigate these issues by compressing larger values, thereby stabilizing the variance across the time series. It also converts multiplicative relationships into additive ones, making the data more suitable for linear modeling.

More importantly, time series data often exhibit non-stationarity due to deterministic trends (systematic upward or downward movements) or stochastic trends (random walks), meaning that their statistical properties change over time. We can apply the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to detect the presence of a unit root.

include Australia, Austria, Belgium, Canada, Denmark, France, Germany, Israel, Italy, Malaysia, Singapore, South Korea, Spain, Switzerland, Thailand, United Kingdom, United States, and Vietnam.

2.3 Forecasting Models

In this section, we consider a few models for forecasting CPI for each category in each country.

1. Autoregressive Integrated Moving Average (ARIMA) Model

If our primary interest merely lies in forecasting future CPIs, the past values of the CPIs can be sufficiently employed to predict their future values, as autocorrelation rather than a causal relationship exhibited in a time series suffices. The baseline econometric forecasting model is an Autoregressive Integrated Moving Average (ARIMA) model:

$$y_{j,c,t} = \beta_{0,j,c} + \sum_{i=1}^{p} \beta_{i,j,c} y_{j,c,t-i} + \sum_{i=1}^{q} \theta_{i,j,c} \varepsilon_{j,c,t-i} + \varepsilon_{j,c,t} \tag{2.1}$$

where $y_{j,c,t}$ is the difference of the logarithm of the CPI for category j in country c at time t, $\varepsilon \sim N(0, \sigma^2)$ is a white-noise disturbance, β and p are the coefficients and lag order of the autoregressive (AR) component, while θ and q are the coefficients and lag order of the moving average (MA) component. To estimate an ARIMA(p, d, q) model, the integration (d) and the lag orders (p, q) must be determined. Since economic theory fails to provide such information, the selection is typically data-driven.

$$\text{ACF}: \quad \rho_{k,j,c} \equiv \text{Corr}\left(y_{j,c,t}, y_{j,c,t+k}\right) = \frac{\text{Cov}\left(y_{j,c,t}, y_{j,c,t+k}\right)}{\text{Var}\left(y_{j,c,t}\right)} \tag{2.2}$$

$$\text{PACF}: \quad \rho^*_{k,j,c} \equiv \text{Corr}\left(y_{j,c,t}, y_{j,c,t+k} \mid y_{j,c,t+1}, \ldots, y_{j,c,t+k-1}\right) \tag{2.3}$$

In empirical applications, the autocorrelation function (ACF)[8] and partial autocorrelation function (PACF)[9] are commonly calculated to determine the order of differencing and assess whether the AR(p) or MA(q) order should be set to zero.

[8] For a sample size n, the ACF at lag k is:$\hat{\rho}_k = \frac{\sum_{t=k+1}^{n}(X_t - \bar{X})(X_{t-k} - \bar{X})}{\sum_{t=1}^{n}(X_t - \bar{X})^2}$, where $\bar{X}$ is the sample mean.

[9] The sample PACF at lag k is defined as the correlation between X_t and $X_(t-k)$, after removing the linear effects of the intermediate lags $X_{t-1}, ..., X_{t-k+1}$. Hence, according to this definition, the sample PACF at lags k, ρ^*_k, is the k-th coefficient of the following linear regression: $X_t = \rho^*_1 X_{t-1} + \rho^*_2 X_{t-2} + \cdots + \rho^*_k X_{t-k} + \epsilon_t$

Normally, the correct amount of differencing is the lowest order of differencing whose autocorrelation function (ACF) plot tails off to zero. If the series still exhibits a long-term trend, or if its autocorrelations are positive out to a high number of lags (e.g., 10 or more), then it needs a higher order of differencing. In our estimation, which we will show later, first or second order differencing is sufficient to remove any remaining non-stationarity. [10]

Moreover, for an AR(p) model, the ACF tails off to zero while PACF cuts off at lag p. In contrast, for a MA(q) model, ACF cuts off at lag q, while the PACF tails off to zero. If both the ACF and PACF gradually tail off, it suggests that neither p nor q is equal to zero. Box, Jenkins, and Reinsel (1994) suggested that in most cases, $p \leq 2$ and $q \leq 2$ are sufficient. However, the maximum lag order tends to be higher in practice, and the optimal one is determined by the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC):

$$\mathrm{AIC}_{j,c} = 2k - 2\ln(\hat{L}_{j,c}) \tag{2.4}$$

$$\mathrm{BIC}_{j,c} = k\ln(n) - 2\ln(\hat{\mathrm{L}}_{\mathrm{j,c}}) \tag{2.5}$$

where $k = p + q + 1$ is the number of estimated parameters and variance term, $\hat{L}_{j,c}$ is the maximized value of the likelihood function, and n is the number of observations. Lower AIC/BIC values indicate a better model among a set of candidate models.

2. Seasonal Autoregressive Integrated Moving Average (SARIMA) Model

Some monthly or quarterly time series exhibit seasonal patterns. For example, quarterly prices for ice cream in the food category may have a strong seasonal component, with high prices in summer and low in autumn. To handle the quarterly effect, a seasonal ARIMA model, often abbreviated SARIMA, can be used. In our forecasting exercise, for simplicity,

[10] For first-order differencing, $y_{j,c,t} = \Delta \ln(\mathrm{CPI}_{j,c,t}) = \ln(\mathrm{CPI}_{j,c,t}) - \ln(\mathrm{CPI}_{j,c,t-1})$; for second-order differencing, $y_{j,c,t} = \Delta^2 \ln(\mathrm{CPI}_{j,c,t}) = \Delta \ln(\mathrm{CPI}_{j,c,t}) - \Delta \ln(\mathrm{CPI}_{j,c,t-1}) = \ln(\mathrm{CPI}_{j,c,t}) - 2\ln(\mathrm{CPI}_{j,c,t-1}) + \ln(\mathrm{CPI}_{j,c,t-2})$

we use a SARIMA$(p,d,q)\times(1,0,1)_4$ model which can be expressed as [11]:

$$y_t = \beta_0 + \sum_{i=1}^{p} \beta_i y_{t-i} + \beta^{'} y_{t-4} - \sum_{i=1}^{p} \beta_i \beta^{'} y_{t-i-4} + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i} + \theta^{'} \varepsilon_{t-4} + \sum_{i=1}^{q} \theta_i \theta^{'} \varepsilon_{t-i-4} + \varepsilon_t \quad (2.6)$$

Here, we consider one seasonal autoregressive term with coefficient $\theta^{'}$, one seasonal moving average term with coefficient $\theta^{'}$, and no seasonal differencing based on the last four quarters. The terms, $\beta_i\beta^{'}$ and $\theta_i\theta^{'}$, imply that the nonseasonal and seasonal factors work multiplicatively on the parameters of the $(i+4)^{th}$-order lagged values.

3. Holt-Winters' Smoothing Model

Holt-Winters smoothing, also known as triple exponential smoothing, can capture seasonality and trend as well. [12] Holt-Winters seasonal method comprises the forecast equation and three smoothing equations — one for the level l_t, one for the trend b_t, and one for the seasonal component s_t, with corresponding smoothing parameters α, β and γ. The component form for the additive method is [13]:

$$\begin{aligned}
\hat{y}_{t+h|t} &= l_t + hb_t + s_{t+h-m(k+1)} \\
l_t &= \alpha(y_t - s_{t-m}) + (1-\alpha)(l_{t-1} + b_{t-1}) \\
b_t &= \beta(l_t - l_{t-1}) + (1-\beta)b_{t-1} \\
s_t &= \gamma(y_t - l_{t-1} - b_{t-1}) + (1-\gamma)s_{t-m}
\end{aligned}$$

where $m = 4$ is the frequency of the seasonality and $\hat{y}_{t+h|t}$ is the forecast for h periods ahead. k is the integer part of $(h-1)/m$, which ensures that the estimates of the seasonal indices used for forecasting come from the final year of the sample. The smoothing parameters (α,

[11] A comprehensive introduction to the SARIMA model is provided in Appendix A. The subscript terms, country j and category c, are omitted to simplify the equation expression.

[12] In time series analysis, seasonality refers to short-term, repeating patterns at fixed intervals while trend refers to the long-term direction of the data.

[13] The Holt-Winters method has two versions, additive and multiplicative, which differ in the nature of the seasonal component. The additive method is preferred when the seasonal variations are roughly constant through the series, while the multiplicative method is preferred when the seasonal variations are changing proportional to the level of the series. The latter is introduced in Appendix A.

β, and γ) are either set or chosen to minimize the in-sample sum-of-squared forecast errors, $e_t = y_t - \hat{y}_{t|t-1} = y_t - (l_{t-1} + b_{t-1} + s_{t-4})$.

2.4 Performance Metrics

Performance metrics such as Root Mean Squared Error (RMSE) and the coefficient of determination (R^2) are employed to evaluate the effectiveness of each model.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (y_i - \widehat{y_l})^2}{n}} \tag{2.7}$$

$$R^2 = 1 - \frac{\sum_{i=1}^{n} (y_i - \widehat{y_l})^2}{\sum_{i=1}^{n} (y_i - \bar{y_l})^2} \tag{2.8}$$

where n is the total number of collected values, y_i, $\hat{y}_i$, and $\bar{y}_i$ are the observed value, predicted value, and mean of the data, respectively. Models with better performance tend to have lower RMSE and higher R-squared.

2.5 ACI Cost of Living Index

To predict item-level prices in 2025, the most straightforward approach is to apply alternative forecasting models introduced above using the past 20 years price data. However, this approach is both impractical and unnecessary. First, estimating a separate model for each item in each city would be computationally intensive.[14] Second, changes in individual item prices do not effectively capture the broader macroeconomic trends at the category level, which are crucial for understanding the distributional effect on the cost of living index. For example, an increase in the price of rice and a decrease in the price of apples does not readily indicate the inflation rate of the food category or its relative contribution to the total consumption basket. Finally, small sample sizes (less than 30) may lead to biased forecasts and exhibit substantial uncertainty. To address these limitations, we impose the following

[14] In our case, the number of forecasting models to be estimated for 165 goods in 45 cities with 3 types of models would be $165 \times 45 \times 3 = 22275$.

assumption:

Assumption 1 *Items within the same category and country share the same inflation rate.*

In other words, the inflation rate of apples in New York is assumed to be the same as that of oranges in Los Angeles. Since category-level CPIs reported by national statistical agencies have already captured price movements of items with similar consumption patterns, national-level inflation rates can be applied to estimate city-level Cost of Living Indices. Nonetheless, this assumption may introduce bias, particularly in countries with significant disparities in income, consumption behavior, and price levels across cities. Accordingly, the price of item i in category j, city k and country c in 2025 can be computed as follows:

$$\begin{aligned} P_{i,k,c}^{2025} &= P_{i,j,k}^{2024} \times (1 + \text{Inflation Rate}_{j,c}^{2025}) \\ &= P_{i,j,k}^{2024} \times (1 + \frac{\text{CPI}_{j,c}^{2025} - \text{CPI}_{j,c}^{2024}}{\text{CPI}_{j,c}^{2024}}) \end{aligned} \tag{2.9}$$

2.5.1 Cost of Living Index for Expatriates

New York has been selected as the base city for this study, aligning with global standards in cost-of-living analyses. Therefore, as a benchmark, New York's index values are fixed at 100.00. We use subscripts k to denote the city of interest and c to denote the country where city k is located. The Cost of Living Index for Expatriates in city k can be computed as follows:

$$CLI_k^E = \frac{\sum_{i=1}^{n} P_{i,k,c}^{2025} \times w_i^E / r_c}{\sum_{i=1}^{n} P_{i,NY,US}^{2025} \times w_i^E} \times 100 \tag{2.10}$$

where n is the total number of items, w_i is the weight of item i in the Cost of Living Index for Expatriates, and r_c is the average exchange rate of the local currency in country c against the US dollar.

2.5.2 Cost of Living Index for Ordinary Residents

The Cost of Living Index for Ordinary Residents in city k can be computed as follows:

$$CLI_k^O = \frac{CP_k \times \frac{NP_c^{ICP}}{NP_c^{EIU}}}{CP_{NY} \times \frac{NP_{US}^{ICP}}{NP_{US}^{EIU}}} \times 100 \tag{2.11}$$

where there are three main components: namely, the price level for city k, CP_k, the national price level based on the ICP survey, NP_c^{ICP}, and the national price level based on the EIU data, NP_c^{EIU}.

The city price, CP_k is computed as:

$$CP_k = \sum_{i=1}^{n} P_{i,k,c}^{2025} \times w_i^O \tag{2.12}$$

Note that the Equation 2.12 takes a form similar to the numerator of Equation 2.10. We can understand CP_m as the cost of living index for ordinary residents who purchase goods and services consumed by expatriates but with their own consumption patterns.

The first adjustment factor, NP_c^{ICP} is constructed using data from the ICP survey, which includes both the nominal expenditure per capita and real expenditure per capita for each country and for the world.

$$NP_c^{ICP} = \frac{NEXP_c/NEXP_{World}}{REXP_c/REXP_{World}} \tag{2.13}$$

where $NEXP$ is the nominal expenditure per capita, and $REXP$ is the real counterpart. The NP_c^{ICP} can be understood as the price level per unit of real consumption for ordinary residents living in country C.

The second adjustment factor, NP_c^{EIU}, is constructed based on CP_k according to the following equation:

$$NP_c^{EIU} = \frac{\sum_{k \in c} CP_k}{N_c} \tag{2.14}$$

where N_c is the number of cities in country c in which city k is located and CP_k is the city price as defined in Equation 2.12. The NP_c^{EIU} is the mean value of CP_k from all cities in country c, which can be understood as a proxy for the general level of CP_k in country c.

3 Results

In this section, we present the main results for the estimated parameters of the forecasting models, inflation rates at both the category and country levels, and the projected cost of living indices and rankings for expatriates and ordinary residents.

3.1 Forecasting Models

Table 1 reports the unit root test results for three categories in the United States: *Food and Non-Alcoholic Beverages*, *Alcohol and Tobacco*, and *Transport*. The findings indicate that the time series is non-stationary at levels, as the p-value for the Augmented Dickey–Fuller and Phillips-Perron tests is statistically insignificant (higher than 0.01) for all lags. However, after taking the first differences of the logarithms, all variables achieve stationarity.

On the basis of the autocorrelations (see Figure 1), lag-length selection for the ARIMA model varies by category. Specifically, the autocorrelation coefficients for *Food and Non-Alcoholic Beverages*, *Alcohol and Tobacco*, and *Transport* are statistically significant at the 5% level at the first, second, and fourth lags, respectively.

Figures 2 - 4 indicate that the predicted values generated by three models are moderately closely aligned with the actual CPI for the selected categories, as the coefficients of determination (R^2) are all close to 1 (see Table 2). However, the model with the lowest RMSE varies by category: ARIMA performs best for *Food and Non-Alcoholic Beverage*, SARIMA for *Alcohol and Tobacco*, and Holt-Winters Smoothing for *Transport*.

Table 1: Unit Root Test

	Food	Alcohol	Transport
	CPI (Level)		
ADF	1.557	6.036	-1.148
	(0.997)	(1.000)	(0.698)
PP	0.725	6.940	-1.307
	(0.990)	(1.000)	(0.626)
	ΔlnCPI		
ADF	-4.476***	-7.287***	-5.980***
	(0.002)	(0.000)	(0.000)
PP	-4.484***	-7.472***	-5.858***
	(0.002)	(0.000)	(0.000)

Notes: This table shows the values of t-statistics and p-values in parentheses on *Food and Non-Alcoholic Beverages, Alcohol and Tobacco, and Transport* in the United States. ***, ** and * imply Significance at 1, 5 and 10 percent level, respectively. *Source:* Asia Competitiveness Institute.

Table 2: Performance Metrics

	Food			Alcohol			Transport		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
RMSE	0.9417	1.1714	1.0090	0.3657	0.3132	0.4974	0.7341	0.8828	0.7209
R^2	0.9963	0.9942	0.9954	0.9995	0.9996	0.9906	0.9240	0.8901	0.9218

Notes: The three columns in each category represent, in order, the ARIMA, SARIMA, and Holt-Winters Smoothing models. *Source:* Asia Competitiveness Institute.

3.2 Inflation Rates

The second column in Table 3 presents the annual inflation rates by category in the United States for 2024, calculated using CPI data reported by the IMF. The third column presents the predicted values generated by the models described above. Overall, the predictions align closely with the observations across most categories. The three categories with the highest inflation rates are *Miscellaneous Goods and Services* (8.44%), *Housing* (4.98%), and *Alcohol and Tobacco* (4.60%). In contrast, the lowest inflation rates are recorded for *Transport* (-3.26%), *Communication* (-1.34%), and *Furnishings* (-0.82%). These rankings are consistent with the estimated results, which are approximately 8.33%, 5.11%, and 4.47% for the top categories, and -3.12%, -1.35%, and -0.59% for the bottom categories, respectively.

Table 3: Annual Inflation Rates by Category in the United States

Category	IMF(2024)	ACI(2024)	ACI(2025)
Food	0.92%	1.17%	1.99%
Alcohol	4.60%	4.47%	3.93%
Clothing	1.27%	0.95%	0.79%
Housing	4.98%	5.11%	4.17%
Furnishings	-0.82%	-0.59%	0.73%
Health	3.54%	3.47%	2.23%
Transport	-3.26%	-3.12%	-0.67%
Communication	-1.34%	-1.35%	-0.33%
Recreation	0.54%	0.78%	0.83%
Education	2.55%	3.20%	3.13%
Miscellaneous	8.44%	8.33%	4.21%
All	2.97%	2.95%	2.60%

Notes: This table presents the annual inflation rates by category for 2024 and 2025 in the United States. The values in the second column are calculated based on observed data, while the values in the third and fourth columns are predicted. *Source:* IMF, Asia Competitiveness Institute.

The fourth column presents the forecast of the average annual inflation rates in the United States for 2025.[15] The inflation rate for all items is projected to be around 2.60%, slightly below the 2.97% in 2024. Among individual categories, *Miscellaneous Goods and Services* is expected to experience the highest inflation at 4.21%, followed by *Housing* (4.17%), and *Alcohol and Tobacco* (3.93%). Conversely, prices are projected to decline slightly in *Transport* (-0.67%) and *Communication* (-0.33%).

Table A.5 presents the average annual inflation rates for all selected countries. Overall, global inflation is projected to decline in 2025. Most countries are expected to experience a faster-than-anticipated decrease, inflation in some emerging markets and developing economies is likely to remain elevated. For instance, India's inflation rate is projected to

[15] Tables A.3 and A.4 report the category-level inflation rate forecasts for all selected countries in 2025.

decline but remain the highest among all selected countries at 4.20% according to the IMF and 4.25% according to our estimates.

However, forecasts can vary notably across organizations. For example, the IMF projects Vietnam's inflation to fall by 0.7%, whereas our model predicts a 0.24% increase. Such discrepancies likely reflect the high volatility of inflation in emerging markets and developing economies, where alternative methodologies can yield divergent outcomes. These differences underscore more granular forecasts, such as category-level inflation rates, for predicting individual prices and cost-of-living rankings.

3.3 Cost of Living Ranking

Tables 4 and 5 list the top-10 and bottom-10 cities in the latest ACI cost of living ranking for expatriates, based on predicted prices for 2025 and actual prices for 2024.[16] As noted in the previous section, higher-ranked cities are more expensive for expatriates to live in than those lower in the ranking. The final column shows ranking movements, where positive values indicate an upward shift, negative values indicate a decline, and zeros denote no change.

Nine of the ten most expensive cities for expatriates among the 45 major cities remain the same between 2024 and 2025, with only minor changes in ranking. In descending order, they are New York, Zurich, Los Angeles, Singapore, Geneva, London, San Francisco, Chicago and Hong Kong. Seattle is the only new entrant to the list, climbing from 11th to 8th place.

Similarly, the ten least expensive cities for expatriates remain unchanged across the two years. In descending order, they are Shenzhen, Bangkok, Osaka/Kobe, Ho Chi Minh, Taipei, Hanoi, Manila, Jakarta, Kuala Lumpur and Mumbai. Most cities experienced minimal changes in ranking, except for Manila, which moved from 43rd to 42nd, and Jakarta, which dropped from 42nd to 43rd.

Tables 6 and 7 list the top-10 and bottom-10 cities in the latest ACI's cost of living

[16] Table A.6 presents the cost-of-living rankings and indices for expatriates in 45 major cities from 2021 to 2025.

Table 4: Top 10 Cities in Cost of Living Ranking for Expatriates

City	Country	Cost of Living Ranking in 2025	Cost of Living Ranking in 2024	Ranking Movements
New York	United States	1st	1st	0
Zurich	Switzerland	2nd	3rd	1
Los Angeles	United States	3rd	2nd	-1
Singapore	Singapore	4th	5th	1
Geneva	Switzerland	5th	4th	-1
London	United Kingdom	6th	6th	0
Seattle	United States	7th	11th	4
San Francisco	United States	8th	8th	0
Chicago	United States	9th	7th	-2
Hong Kong	Hong Kong, China	10th	10th	0

Notes: Cities are arranged in descending order of the latest ranking result.
Source: Asia Competitiveness Institute

Table 5: Bottom 10 Cities in Cost of Living Ranking for Expatriates

City	Country	Cost of Living Ranking in 2025	Cost of Living Ranking in 2024	Ranking Movements
Shenzhen	China	36th	36th	0
Bangkok	Thailand	37th	37th	0
Osaka/ Kobe	Japan	38th	38th	0
Ho Chi Minh	Vietnam	39th	39th	0
Taipei	Taiwan, China	40th	40th	0
Hanoi	Vietnam	41th	41th	0
Manila	Philippines	42th	43th	1
Jakarta	Indonesia	43th	42th	-1
Kuala Lumpur	Malaysia	44th	44th	0
Mumbai	India	45th	45th	0

Notes: Cities are arranged in descending order of the latest ranking result.
Source: Asia Competitiveness Institute

Table 6: Top 10 Cities in Cost of Living Ranking for Ordinary Residents

City	Country	Cost of Living Ranking in 2025	Cost of Living Ranking in 2024	Ranking Movements
New York	United States	1st	1st	0
Zurich	Switzerland	2nd	3rd	1
Los Angeles	United States	3rd	2nd	-1
Geneva	Switzerland	4th	4th	0
Seattle	United States	5th	8th	3
Chicago	United States	6th	6th	0
San Francisco	United States	7th	7th	0
Washington DC	United States	8th	9th	1
Sydney	Australia	9th	5th	-4
Minneapolis	United States	10th	12th	2

Notes: Cities are arranged in descending order of the latest ranking result.
Source: Asia Competitiveness Institute

Table 7: Bottom 10 Cities in Cost of Living Ranking for Ordinary Residents

City	Country	Cost of Living Ranking in 2025	Cost of Living Ranking in 2024	Ranking Movements
Shenzhen	China	36th	36th	0
Beijing	China	37th	37th	0
Taipei	Taiwan, China	38th	38th	0
Manila	Philippines	39th	39th	0
Jakarta	Indonesia	40th	40th	0
Kuala Lumpur	Malaysia	41th	41th	0
Bangkok	Thailand	42th	42th	0
Hanoi	Vietnam	43th	44th	1
Ho Chi Minh	Vietnam	44th	45th	1
Mumbai	India	45th	43th	-2

Notes: Cities are arranged in descending order of the latest ranking result.
Source: Asia Competitiveness Institute

ranking for ordinary residents.[17] Most cities retain their rankings with minor fluctuations. Seattle moves up from 8th to 5th place, Minneapolis rises from 12th to 10th place, while Sydney drops from 5th to 9th. Overall, the list remains dominated by U.S. cities, which account for seven of the ten most expensive locations. Lastly, the list of the bottom-10 cities in 2025 is identical to that in 2024. Hanoi and Ho Chi Minh, both in Vietnam, become relatively more expensive compared with other cities in this group.

4 Discussion

Tables 4, 5 and A.6 reveal distinct regional patterns: over the past few years, the most expensive cities for expatriates have been concentrated in North America and Western Europe, with Singapore and Hong Kong standing out as notable exceptions. Unsurprisingly, the least expensive cities are predominantly distributed in Southeast Asia where the indices are less than 50 and continue to decline. These regional contrasts become even more pronounced when examining the rankings for ordinary residents. For example, in Mumbai, the 2025 cost of living index for ordinary residents (15.72) is roughly half that for expatriates (31.69). The results indicate that cities in developed regions generally have a higher cost of living compared to those in developing regions, and are becoming increasingly unaffordable.

More importantly, the cases of higher-ranking cities —Zurich, Singapore, and Hong Kong —indicate that factors beyond regional economic development, such as housing markets, transportation costs, education fees, and persistent inflationary pressures, have substantially contributed to elevated living costs, as shown in Table 8.[18] Specifically, the costs of housing rank the highest in most of the top ten most expensive cities. Meanwhile, goods in *Transportation* and *Education* are the most expensive for expatriates in Singapore, while they rank fifth and sixth in Hong Kong, respectively.

[17] Table A.7 presents the cost-of-living rankings and indices for ordinary residents in 45 major cities from 2021 to 2025.

[18] Tables A.8 and A.9 present the cost-of-living rankings by category in 45 major cities for expatriates and ordinary residents respectively.

Table 8: Cost of Living Indices and Rankings by Category

	Housing			Transport			Education		
	EX	OR	Rate	EX	OR	Rate	EX	OR	Rate
New York	100 (1)	100 (1)	4.17%	100 (26)	100 (5)	-0.67%	100 (4)	100 (3)	3.13%
Zurich	47.69 (7)	58.17 (3)	1.89%	147.13 (4)	98.13 (8)	-0.84%	97.10 (5)	102.23 (2)	0.67%
Singapore	48.32 (6)	40.31 (23)	3.05%	304.53 (1)	58.90 (24)	2.95%	124.87 (1)	42.56 (28)	2.15%
Hong Kong	53.70 (4)	40.80 (21)	3.06%	146.02 (5)	57.39 (25)	2.18%	95.73 (6)	48.74 (24)	1.63%

Notes: This table presents the cost-of-living indices and rankings for *Housing Rents and Utilities*, *Transport* and *Education*, differentiated by expatriates (EX), ordinary residents (OR) and inflation rates, for New York, Zurich, Singapore, and Hong Kong. Rankings are reported in parentheses.
Source: Asia Competitiveness Institute

A key driver of housing costs is the imbalance between housing supply and demand, which is particularly challenging in cities with high population inflows or constrained by limited land available for development. In addition, rising construction costs and land prices further elevate housing prices. For expatriates, the burden is greater, as they primarily rely on the private rental and condominium market, where prices are substantially higher compared to the public rental or subsidized housing available to residents. This argument is supported by the fact that housing costs for ordinary residents rank only 23rd in Singapore and 21st in Hong Kong.

Similarly, transportation costs mainly come from private car ownership. Expatriate consumption patterns typically assume a preference for owning or leasing cars. In Singapore, for example, car ownership is the most expensive in the world due to the COE (Certificate of Entitlement). As a result, the projected average price of a 900–1299 cc passenger car in 2025 is about 104,000 dollars in Singapore, compared to 30,000 dollars in New York. The transportation index for expatriates in Singapore (304.53) is roughly three times that in New York (100). In contrast, public transport such as the MRT and buses is relatively affordable, reliable, and widely used by residents, resulting in much lower living costs for ordinary residents. The analysis can also apply to education costs, which usually refer to international school fees in the EIU survey. Furthermore, persistently high inflation rates suggest that these three factors —housing, transportation, and education —may become increasingly important in shaping expatriate living costs.

Last but not least, exchange-rate fluctuations directly affect the pay and savings of internationally mobile employees, especially since the prices of goods and services in the surveyed cities are converted into US dollars to facilitate cross-city comparisons. As shown in Figure 5, strong exchange rates (e.g., Singapore and the Euro area) contribute to higher rankings relative to other cities with weaker exchange rates (e.g., China, Japan, and India). However, stronger currencies do not raise the cost of living for ordinary residents who earn in local currencies. On the contrary, currency appreciation helps dampen imported inflation by reducing the local-currency prices of imports, thereby easing consumer prices.

5 Conclusion

This study develops a forecasting framework for cost-of-living rankings across 45 major cities, extending the literature beyond retrospective comparisons. By combining established time-series models with detailed expenditure weights for expatriates and ordinary residents, it captures how macroeconomic shocks, local price structures, and exchange-rate movements shape urban affordability.

The results point to three main insights. First, relative rankings are generally stable over time, with cities in developed economies consistently occupying the top tier. Second, for expatriates, housing markets, transportation costs, and international school fees emerge as the most decisive drivers of cost pressures, amplified by currency fluctuations. Third, for ordinary residents, regional disparities are more pronounced: residents in developed regions continue to face substantially higher living costs.

These findings have practical implications. Businesses can use forward-looking rankings to calibrate expatriate compensation packages; policymakers can better anticipate affordability challenges in high-cost cities; and internationally mobile professionals can make more informed decisions about relocation. At the same time, the forecasts remain subject to uncertainty, especially in light of unpredictable shocks such as geopolitical tensions, abrupt policy shifts, or tariffs. Future work could integrate scenario analysis, micro-level household expenditure data, and machine-learning techniques to improve robustness and capture heterogeneity in cost-of-living experiences.

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Tables

Table A.1: List of Cities Covered in the 2025 ACI Annual Cost of Living Forecast

No.	**City**	**Country**	**Region**
1	Atlanta	United States	North America
2	Bangkok	Thailand	Asia
3	Barcelona	Spain	Western Europe
4	Beijing	China	Asia
5	Boston	United States	North America
6	Brussels	Belgium	Western Europe
7	Chicago	United States	North America
8	Cleveland	United States	North America
9	Copenhagen	Denmark	Western Europe
10	Frankfurt	Germany	Western Europe
11	Geneva	Switzerland	Western Europe
12	Hong Kong	Hong Kong, China	Asia
13	Honolulu	United States	North America
14	Houston	United States	North America
15	Jakarta	Indonesia	Asia
16	Kuala Lumpur	Malaysia	Asia
17	London	United Kingdom	Western Europe
18	Los Angeles	United States	North America
19	Madrid	Spain	Western Europe
20	Manila	Philippines	Asia
21	Melbourne	Australia	Australasia
22	Miami	United States	North America
23	Milan	Italy	Western Europe
24	Minneapolis	United States	North America
25	Mumbai	India	Asia
26	New York	United States	North America
27	Osaka/Kobe	Japan	Asia
28	Paris	France	Western Europe
29	Pittsburgh	United States	North America
30	San Francisco	United States	North America
31	Seattle	United States	North America

Table A.1: List of Cities Covered in the 2025 ACI Annual Cost of Living Forecast (continued)

No.	**City**	**Country**	**Region**
32	Seoul	South Korea	Asia
33	Shanghai	China	Asia
34	Shenzhen	China	Asia
35	Singapore	Singapore	Asia
36	Sydney	Australia	Australasia
37	Taipei	Taiwan, China	Asia
38	Tel Aviv	Israel	Asia
39	Tokyo	Japan	Asia
40	Toronto	Canada	North America
41	Vienna	Austria	Western Europe
42	Washington DC	United States	North America
43	Zurich	Switzerland	Western Europe
44	Hanoi	Vietnam	Asia
45	Ho Chi Minh	Vietnam	Asia

Source: Asia Competitiveness Institute

Table A.2: Classification of Individual Consumption by Organization/Country

IMF	**China**	**Hong Kong**	**India**
Food and Non-alcoholic beverages	Food, Tobacco and Liquor	Food	Food and Beverage
Alcoholic beverages, Tobacco, and Narcotics	Clothing and Footwear	Alcoholic beverages and Tobacco	Pan, Tobacco and Intoxicants
Clothing and Footwear	Residence	Clothing and Footwear	Clothing and Footwear
Housing, Water, Electricity, Gas, and Fuels	Household facilities, Articles and Services	Housing	Housing
Furnishings, Household equipment, and Routine household maintenance	Health care and medical services	Electricity, Gas, and Water	Fuel and Light
Health	Transportation and Telecommunication	Durable goods	Miscellaneous goods and services
Transport	Education, Culture and Recreation	Transport	
Communication	Other articles and services	Miscellaneous goods	
Recreation and Culture		Miscellaneous services	
Education			
Miscellaneous goods and services			

Japan	**Indonesia**	**Philippines**	**Taiwan**
Food and Non-alcoholic beverages	Food, Beverages and Tobacco	Food and Non-alcoholic beverages	Food
Alcoholic beverages, Tobacco, and Narcotics	Clothing and Footwear	Alcoholic beverages, and Tobacco	Alcoholic beverages
Clothing and Footwear	Housing, Water, Electricity, Gas and Fuels	Clothing and Footwear	Tobacco
Housing, Fuel, Light, Water	Furnishings, Household equipment, and Routine household maintenance	Housing, Water, Electricity, Gas, and Fuels	Clothing and Footwear
Furniture and Household utensils	Health	Furnishings, Household equipment, and Routine household maintenance	Housing
Medical care	Transport	Health	Transportation and Communication
Transportation and Communication	Information, Communication and Financial Services	Transport, Information and Communication	Health
Education	Recreation, Sport and Culture	Education	Education and Entertainment
Culture and Recreation	Education	Recreation and Culture	Miscellaneous
Miscellaneous	Personal Care and Other Services	Miscellaneous goods and services	

Table A.3: 2025 Annual Inflation Rates by Category

Category	United States	Australia	Austria	Belgium	Canada	Denmark	France	Germany	United Kingdom
Food	1.99%	2.86%	2.33%	2.84%	2.68%	4.37%	1.38%	2.70%	2.12%
Alcoholic	3.93%	6.12%	2.77%	7.69%	3.01%	4.12%	4.01%	3.62%	5.62%
Clothing	0.79%	1.86%	1.62%	1.32%	-0.34%	-0.07%	1.49%	3.35%	2.19%
Housing	4.17%	-0.07%	1.19%	4.45%	4.23%	1.89%	3.03%	1.61%	6.88%
Furnishings	0.73%	2.07%	0.51%	3.36%	1.60%	-0.10%	0.76%	-0.66%	0.81%
Health	2.23%	4.87%	4.40%	2.35%	3.79%	1.72%	-0.91%	2.48%	4.57%
Transport	-0.67%	2.71%	1.08%	2.57%	3.19%	1.49%	4.19%	1.92%	2.07%
Communication	-0.33%	-0.10%	-3.95%	-0.33%	-5.35%	0.53%	-8.05%	-1.52%	4.01%
Recreation	0.83%	2.97%	4.09%	2.68%	2.68%	2.60%	1.70%	2.28%	4.44%
Education	3.13%	5.85%	2.32%	2.65%	1.44%	3.90%	2.98%	4.04%	3.85%
Miscellaneous	4.21%	3.97%	3.94%	4.16%	4.74%	4.05%	3.70%	5.96%	2.93%
All	2.60%	2.49%	1.04%	2.83%	2.19%	2.26%	1.86%	1.91%	3.04%

Category	Israel	Italy	Malaysia	Singapore	South Korea	Spain	Switzerland	Thailand	Vietnam
Food	4.75%	2.68%	2.87%	1.48%	3.32%	0.85%	1.86%	3.15%	6.90%
Alcoholic	6.03%	2.10%	3.00%	0.75%	0.47%	4.02%	0.78%	2.52%	1.69%
Clothing	-5.75%	1.46%	-0.07%	-0.54%	1.93%	0.71%	-0.17%	0.10%	0.21%
Housing	3.94%	-3.14%	2.03%	3.05%	2.08%	1.74%	1.89%	0.88%	5.22%
Furnishings	-1.86%	-0.07%	1.17%	0.78%	2.34%	0.60%	-1.21%		1.75%
Health	1.86%	1.01%	1.11%	2.90%	1.59%	1.07%	-0.39%	0.30%	7.58%
Transport	5.00%	1.30%	1.28%	2.95%	1.82%	1.19%	-0.84%	2.87%	-0.70%
Communication	-2.60%	-3.80%	-3.35%	-0.67%	-0.19%	0.25%	1.23%		-1.17%
Recreation	3.10%	1.29%	1.33%	2.13%	0.65%	2.77%	1.75%	0.62%	2.88%
Education	2.51%	2.13%	1.63%	2.15%	1.93%	0.44%	0.67%		4.89%
Miscellaneous	2.35%	1.93%	1.96%	0.50%	3.02%	3.06%	0.23%		7.92%
All	3.69%	2.17%	1.97%	2.10%	2.21%	2.28%	0.93%	1.91%	3.84%

Note: This table presents the 2025 inflation rates by category for countries whose CPI data are sourced from the IMF.

Table A.4: 2025 Annual Inflation Rates by Category (continued)

(a) Japan

Category	Inflation
Food	4.01%
Alcoholic	6.72%
Tobacco	2.88%
Housing	3.56%
Fuel	2.76%
Furniture	2.75%
Clothes	1.50%
Medical	0%
Transportation	1.60%
Education	-0.79%
Culture	3.69%
Miscellaneous	1.19%
All	3.46%

(b) Philippines

Category	Inflation
Food	4.01%
Alcoholic	6.72%
Clothing	2.88%
Housing	3.56%
Furnishings	2.76%
Health	2.75%
Transport	1.50%
Communication	0.40%
Recreation	2.94%
Education	5.38%
Miscellaneous	2.72%
All	3.49%

(c) Taiwan, China

Category	Inflation
Food	2.43%
Alcoholic	-0.13%
Tobacco	3.34%
Clothing	0.11%
Residential	2.28%
Electricity	3.76%
Transportation	0.13%
Health	2.11%
Educational	1.42%
Recreation	4.51%
Miscellaneous	1.45%
All	1.40%

(d) Hong Kong, China

Category	Inflation
Food	2.06%
Alcoholic	5.15%
Clothing	-0.71%
Housing	3.06%
Durable	-0.80%
Electricity	1.87%
Transport	2.18%
Miscellaneous goods	1.03%
Miscellaneous services	1.61%
All	2.21%

(e) Indonesia

Category	Inflation
Food	4.06%
Clothing	0.82%
Housing	-8.17%
Furnishing	0.82%
Health	1.40%
Transport	0.67%
Communication	-0.04%
Recreation	0.92%
Education	1.10%
Miscellaneous	5.48%
All	1.07%

(f) China

Category	Inflation
Food	-0.19%
Clothing	1.25%
Household	0.42%
Residence	0.89%
Health	1.16%
Transportation	-0.42%
Education	1.55%
Miscellaneous	3.00%
All	0.23%

(g) India

Category	India
Food	6.09%
Tobacco	5.30%
Clothing	4.40%
Housing	4.38%
Fuel	1.74%
Miscellaneous	5.14%
All	4.25%

Note: This table presents the 2025 inflation rates by category for countries whose CPI data are sourced from national statistical agencies.

Table A.5: Annual Inflation Rates For All Items

Country	IMF(2024)	IMF(2025)	ACI(2025)
Australia	3.20%	2.50%	2.49%
Austria	2.90%	3.20%	2.90%
Belgium	4.30%	3.20%	2.83%
Canada	2.40%	2.00%	2.19%
China	0.20%	0.00%	0.23%
Denmark	1.30%	1.90%	2.26%
France	2.30%	1.30%	1.86%
Germany	2.50%	2.10%	1.91%
Hong Kong, China	1.70%	1.90%	2.21%
India	4.70%	4.20%	4.25%
Indonesia	2.30%	1.70%	1.07%
Israel	3.10%	2.70%	3.69%
Italy	1.10%	1.70%	2.17%
Japan	2.70%	2.40%	2.46%
Malaysia	1.80%	2.40%	1.97%
Philippines	3.20%	2.60%	3.49%
Singapore	2.40%	1.30%	2.10%
South Korea	2.30%	1.80%	2.21%
Spain	2.90%	2.20%	2.28%
Switzerland	1.10%	0.20%	0.93%
Taiwan, China	2.20%	1.80%	1.40%
Thailand	0.40%	0.70%	0.91%
United Kingdom	2.50%	3.10%	3.04%
United States	3.00%	3.00%	2.60%
Vietnam	3.60%	2.90%	3.84%

Note: This table presents the average annual inflation rates for all selected countries. The second and third columns show the rates reported by the IMF for 2024 and 2025, respectively. The last column presents the rates predicted by our models.

Table A.6: Cost of Living Rankings and Indices for Expatriates in 45 Major Cities

No.	City	Country	Year				
			2021	2022	2023	2024	2025
1	New York	United States	100 (1)	100 (1)	100 (1)	100 (1)	100 (1)
2	Atlanta	United States	58.68 (22)	60.08 (16)	60.53 (17)	62.11 (16)	62.32 (18)
3	Bangkok	Thailand	52.96 (37)	47.64 (37)	47.92 (37)	46.40 (37)	49.22 (37)
4	Barcelona	Spain	54.61 (34)	50.04 (29)	51.38 (32)	53.99 (29)	55.56 (30)
5	Beijing	China	57.01 (29)	52.83 (34)	50.36 (34)	50.32 (34)	50.19 (34)
6	Boston	United States	62.05 (19)	62.16 (13)	62.06 (15)	63.98 (13)	64.71 (17)
7	Brussels	Belgium	51.76 (38)	46.89 (35)	48.70 (36)	50.15 (35)	53.70 (32)
8	Chicago	United States	66.86 (13)	68.03 (7)	68.84 (6)	69.59 (7)	69.34 (9)
9	Cleveland	United States	57.98 (26)	58.06 (20)	58.47 (19)	59.81 (20)	60.09 (23)
10	Copenhagen	Denmark	68.79 (12)	60.44 (18)	62.95 (14)	61.41 (18)	64.91 (15)
11	Frankfurt	Germany	70.46 (8)	61.96 (14)	63.10 (13)	63.83 (14)	66.19 (14)
12	Geneva	Switzerland	76.23 (4)	70.92 (4)	75.22 (4)	76.59 (4)	78.67 (5)
13	Hanoi	Vietnam	45.21 (42)	43.34 (41)	42.66 (42)	42.97 (41)	44.61 (41)
14	Ho Chi Minh	Vietnam	48.15 (40)	45.40 (39)	44.52 (39)	44.10 (39)	45.59 (39)
15	Hong Kong	Hong Kong, China	71.07 (7)	67.70 (10)	67.37 (7)	67.90 (10)	69.02 (10)
16	Honolulu	United States	58.66 (23)	57.87 (22)	57.91 (21)	58.82 (22)	60.91 (20)

Table A.6: Cost of Living Rankings and Indices for Expatriates (continued)

No.	City	Country	Year				
			2021	2022	2023	2024	2025
17	Houston	United States	57.24	57.09	57.24	58.81	60.17
			(28)	(23)	(23)	(23)	(22)
18	Jakarta	Indonesia	46.48	43.99	43.28	41.46	39.97
			(41)	(42)	(40)	(42)	(43)
19	Kuala Lumpur	Malaysia	34.22	31.93	31.52	31.46	34.55
			(44)	(44)	(44)	(44)	(44)
20	London	Great Britain	70.40	64.83	67.02	70.24	73.26
			(9)	(6)	(9)	(6)	(6)
21	Los Angeles	United States	82.74	83.87	81.98	81.96	83.08
			(2)	(2)	(2)	(2)	(3)
22	Madrid	Spain	54.83	50.02	51.69	54.35	56.03
			(33)	(28)	(31)	(28)	(29)
23	Manila	Philippines	42.78	38.82	38.68	38.96	40.04
			(43)	(43)	(43)	(43)	(42)
24	Melbourne	Australia	58.76	54.17	53.71	55.76	58.25
			(21)	(27)	(27)	(27)	(26)
25	Miami	United States	58.15	58.08	58.08	59.62	61.26
			(24)	(21)	(20)	(21)	(19)
26	Milan	Italy	56.98	52.13	54.97	56.40	58.11
			(30)	(25)	(26)	(25)	(27)
27	Minneapolis	United States	62.47	62.02	61.99	63.03	64.74
			(18)	(15)	(16)	(15)	(16)
28	Mumbai	India	33.20	30.72	29.42	29.71	31.69
			(45)	(45)	(45)	(45)	(45)
29	Osaka / Kobe	Japan	58.09	47.73	46.38	44.60	48.44
			(25)	(38)	(38)	(38)	(38)
30	Paris	France	74.12	63.04	65.04	65.52	67.87
			(5)	(12)	(12)	(12)	(12)
31	Pittsburgh	United States	56.70	56.15	56.31	57.44	59.47
			(31)	(24)	(25)	(24)	(24)
32	San Francisco	United States	65.15	64.87	67.04	68.98	69.59
			(15)	(8)	(8)	(8)	(8)

Table A.6: Cost of Living Rankings and Indices for Expatriates (continued)

No.	City	Country	Year				
			2021	2022	2023	2024	2025
33	Seattle	United States	65.19	66.96	66.90	67.86	69.77
			(14)	(11)	(10)	(11)	(7)
34	Seoul	South Korea	57.92	51.32	50.77	50.55	49.99
			(27)	(33)	(33)	(33)	(35)
35	Shanghai	China	59.44	55.40	52.64	51.69	51.13
			(20)	(32)	(28)	(32)	(33)
36	Shenzhen	China	55.43	51.82	49.51	49.32	49.59
			(32)	(36)	(35)	(36)	(36)
37	Singapore	Singapore	73.49	71.39	74.10	76.24	79.57
			(6)	(5)	(5)	(5)	(4)
38	Sydney	Australia	62.98	57.59	56.84	59.99	60.76
			(17)	(19)	(24)	(19)	(21)
39	Taipei	Taiwan, China	48.76	44.35	43.10	43.61	45.27
			(39)	(40)	(41)	(40)	(40)
40	Tel Aviv	Israel	69.96	65.06	60.48	61.71	66.72
			(11)	(17)	(18)	(17)	(13)
41	Tokyo	Japan	69.96	59.76	57.59	55.97	59.15
			(10)	(26)	(22)	(26)	(25)
42	Toronto	Canada	53.59	52.65	52.43	53.71	55.15
			(36)	(30)	(29)	(30)	(31)
43	Vienna	Austria	54.34	49.02	52.21	53.36	56.34
			(35)	(31)	(30)	(31)	(28)
44	Washington DC	United States	65.01	65.12	65.96	67.95	68.38
			(16)	(9)	(11)	(9)	(11)
45	Zurich	Switzerland	81.49	75.98	80.69	81.00	83.25
			(3)	(3)	(3)	(3)	(2)

Notes: Numbers in parentheses are the cost of living rankings.

Source: Asia Competitiveness Institute

Table A.7: Cost of Living Rankings and Indices for Ordinary Residents in 45 Major Cities

No.	City	Country	Year				
			2021	2022	2023	2024	2025
1	New York	United States	100.00 (1)	100.00 (1)	100.00 (1)	100.00 (1)	100.00 (1)
2	Atlanta	United States	57.53 (24)	59.77 (18)	59.98 (16)	61.47 (16)	61.76 (18)
3	Bangkok	Thailand	19.61 (42)	17.82 (42)	17.49 (42)	16.71 (42)	17.28 (42)
4	Barcelona	Spain	46.73 (31)	42.40 (32)	43.43 (31)	44.12 (30)	45.66 (30)
5	Beijing	China	38.21 (37)	35.06 (37)	32.10 (37)	31.68 (37)	28.57 (37)
6	Boston	United States	62.58 (16)	63.45 (14)	63.12 (13)	64.88 (11)	64.86 (12)
7	Brussels	Belgium	54.33 (27)	49.66 (26)	51.15 (26)	52.78 (26)	54.59 (24)
8	Chicago	United States	68.47 (9)	69.52 (6)	69.94 (5)	70.63 (6)	70.61 (6)
9	Cleveland	United States	56.87 (25)	57.53 (21)	57.90 (21)	59.42 (21)	60.14 (21)
10	Copenhagen	Denmark	67.43 (10)	60.54 (15)	61.82 (15)	62.18 (15)	64.31 (13)
11	Frankfurt	Germany	62.31 (17)	54.88 (24)	56.77 (24)	57.02 (24)	50.67 (25)
12	Geneva	Switzerland	80.66 (4)	74.52 (4)	77.80 (4)	79.17 (4)	81.92 (4)
13	Hanoi	Vietnam	16.56 (45)	16.10 (44)	15.59 (45)	15.99 (44)	16.56 (43)
14	Ho Chi Minh	Vietnam	16.84 (44)	16.07 (45)	15.68 (44)	15.94 (45)	16.46 (44)
15	Hong Kong	Hong Kong, China	46.43 (32)	44.06 (29)	43.29 (32)	43.61 (31)	45.10 (31)
16	Honolulu	United States	59.60 (19)	59.80 (16)	59.74 (17)	60.72 (18)	62.19 (16)

Table A.7: Cost of Living Rankings and Indices for Ordinary Residents (continued)

No.	City	Country	Year				
			2021	2022	2023	2024	2025
17	Houston	United States	58.96 (21)	59.61 (19)	59.28 (19)	60.69 (19)	61.41 (19)
18	Jakarta	Indonesia	23.06 (40)	21.72 (40)	21.11 (40)	20.42 (40)	21.12 (40)
19	Kuala Lumpur	Malaysia	21.12 (41)	19.29 (41)	18.36 (41)	18.03 (41)	18.65 (41)
20	London	Great Britain	61.49 (18)	55.74 (23)	57.81 (22)	59.84 (20)	61.89 (17)
21	Los Angeles	United States	85.89 (3)	87.26 (2)	85.09 (2)	84.45 (2)	84.72 (3)
22	Madrid	Spain	47.52 (30)	42.80 (31)	43.89 (30)	44.63 (29)	46.13 (29)
23	Manila	Philippines	26.16 (39)	23.49 (39)	23.47 (39)	23.35 (39)	24.15 (39)
24	Melbourne	Australia	73.78 (6)	67.82 (9)	65.68 (10)	66.46 (10)	64.25 (14)
25	Miami	United States	59.14 (20)	59.79 (17)	59.55 (18)	61.20 (17)	62.48 (15)
26	Milan	Italy	51.76 (28)	47.24 (28)	49.50 (27)	49.84 (27)	48.65 (26)
27	Minneapolis	United States	63.96 (15)	63.94 (13)	63.50 (12)	64.42 (12)	65.76 (10)
28	Mumbai	India	17.30 (43)	16.20 (43)	15.68 (43)	16.09 (43)	15.72 (45)
29	Osaka / Kobe	Japan	48.15 (29)	37.55 (35)	34.88 (35)	31.94 (35)	33.16 (34)
30	Paris	France	64.87 (14)	55.92 (22)	57.33 (23)	57.29 (23)	47.78 (27)
31	Pittsburgh	United States	57.94 (23)	58.08 (20)	58.18 (20)	59.30 (22)	60.65 (20)
32	San Francisco	United States	66.42 (12)	67.00 (10)	68.43 (8)	70.20 (7)	70.13 (7)

Table A.7: Cost of Living Rankings and Indices for Ordinary Residents (continued)

No.	City	Country	Year				
			2021	2022	2023	2024	2025
33	Seattle	United States	66.53	69.02	69.00	70.15	71.45
			(11)	(7)	(6)	(8)	(5)
34	Seoul	South Korea	44.31	38.71	38.17	37.30	38.58
			(34)	(34)	(33)	(33)	(33)
35	Shanghai	China	43.43	39.36	35.68	34.26	30.98
			(35)	(33)	(34)	(34)	(35)
36	Shenzhen	China	39.02	35.65	32.58	31.76	29.23
			(36)	(36)	(36)	(36)	(36)
37	Singapore	Singapore	44.40	43.07	44.60	45.12	46.66
			(33)	(30)	(29)	(28)	(28)
38	Sydney	Australia	77.94	71.27	68.83	71.15	66.49
			(5)	(5)	(7)	(5)	(9)
39	Taipei	Taiwan, China	29.37	26.59	25.09	24.65	25.49
			(38)	(38)	(38)	(38)	(38)
40	Tel Aviv	Israel	72.57	68.29	62.40	63.53	65.71
			(7)	(8)	(14)	(14)	(11)
41	Tokyo	Japan	58.39	48.02	44.68	41.96	43.27
			(22)	(27)	(28)	(32)	(32)
42	Toronto	Canada	68.52	65.93	64.61	63.84	59.53
			(8)	(11)	(11)	(13)	(22)
43	Vienna	Austria	55.56	50.29	53.68	54.71	56.58
			(26)	(25)	(25)	(25)	(23)
44	Washington DC	United States	65.30	65.89	66.63	68.66	69.03
			(13)	(12)	(9)	(9)	(8)
45	Zurich	Switzerland	86.87	80.21	83.75	84.21	87.05
			(2)	(3)	(3)	(3)	(2)

Notes: Numbers in parentheses are the cost of living rankings.

Source: Asia Competitiveness Institute

Table A.8: Cost of Living Rankings by Category for Expatriates

No.	City	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	New York	1	4	1	1	1	1	26	7	4	4
2	Atlanta	14	26	37	23	6	22	33	39	13	10
3	Bangkok	21	30	24	25	43	34	14	36	9	42
4	Barcelona	41	39	10	20	20	14	20	6	43	34
5	Beijing	23	23	9	34	39	40	19	13	8	38
6	Boston	10	17	7	18	14	19	38	22	17	10
7	Brussels	26	28	36	41	24	29	17	41	29	22
8	Chicago	30	10	26	17	16	2	29	24	21	7
9	Cleveland	8	29	43	39	7	12	37	35	15	10
10	Copenhagen	18	22	29	38	8	10	3	4	41	2
11	Frankfurt	28	36	14	21	18	7	9	10	31	8
12	Geneva	6	25	13	8	3	5	6	3	10	3
13	Hanoi	27	37	35	36	38	33	12	26	25	43
14	Ho Chi Minh	31	38	39	14	41	38	10	38	39	43
15	Hong Kong	2	12	28	4	30	26	5	16	6	33
16	Honolulu	32	24	25	19	22	21	27	34	27	10
17	Houston	40	19	38	27	26	13	23	20	20	10
18	Jakarta	34	11	41	40	44	43	35	44	16	40
19	Kuala Lumpur	36	15	44	45	40	41	40	43	38	39
20	London	42	5	12	3	12	8	7	17	12	26
21	Los Angeles	12	6	4	2	2	6	16	14	7	29
22	Madrid	37	41	8	24	21	15	21	8	45	32
23	Manila	44	43	42	28	42	44	39	40	23	41
24	Melbourne	39	1	15	29	25	31	22	18	28	23
25	Miami	33	31	32	22	19	16	31	29	24	9

Table A.8: Cost of Living Rankings by Category for Expatriates (continued)

No.	City	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
26	Milan	38	42	2	33	28	11	13	15	44	21
27	Minneapolis	19	14	20	26	10	9	32	37	14	10
28	Mumbai	45	16	45	44	45	45	11	45	32	45
29	Osaka / Kobe	17	44	30	43	32	39	41	25	40	5
30	Paris	25	9	11	9	13	24	15	5	19	20
31	Pittsburgh	29	27	19	35	15	17	24	30	26	10
32	San Francisco	11	8	34	5	4	23	28	19	18	10
33	Seattle	20	18	27	10	9	3	25	32	22	10
34	Seoul	7	32	6	32	35	35	36	21	30	35
35	Shanghai	15	40	23	31	37	30	34	27	11	36
36	Shenzhen	5	33	16	37	34	36	44	31	3	37
37	Singapore	9	3	3	6	33	28	1	12	1	31
38	Sydney	35	2	21	13	27	32	18	23	35	23
39	Taipei	22	35	22	42	36	42	30	42	36	27
40	Tel Aviv	16	7	18	12	29	25	2	2	34	25
41	Tokyo	4	45	31	11	31	37	45	11	37	5
42	Toronto	43	20	40	15	17	27	43	33	33	28
43	Vienna	13	34	33	30	23	20	8	9	42	30
44	Washington DC	24	13	5	16	11	18	42	28	2	10
45	Zurich	3	21	17	7	5	4	4	1	5	1

Notes: This table shows the cost-of-living rankings by category for expatriates among 45 major countries. Based on the consumption basket proposed by ACI , the ten categories are: (1) *Food and Non-Alcoholic Beverages*, (2) *Alcohol and Tobacco*, (3) *Clothing and Footwear*, (4) *Housing Rents and Utilities*, (5) *Household Supplies and Domestic Help*, (6) *Health*, (7) *Transport*, (8) *Recreation*, (9) *Education*, and (10) *Miscellaneous Goods and Services.*

Source: Asia Competitiveness Institute

Table A.9: Cost of Living Rankings by Category for Ordinary Residents

No.	City	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	New York	4	5	1	1	3	1	5	2	3	3
2	Atlanta	18	23	36	30	24	22	13	26	8	6
3	Bangkok	43	39	41	38	41	45	42	41	42	40
4	Barcelona	33	33	26	18	17	27	28	29	34	29
5	Beijing	38	25	7	31	40	38	34	35	32	37
6	Boston	11	19	8	25	27	16	15	12	12	6
7	Brussels	20	21	16	13	10	23	26	16	20	21
8	Chicago	32	11	20	17	28	4	9	13	15	4
9	Cleveland	8	26	40	39	19	13	14	23	7	6
10	Copenhagen	15	14	6	9	4	8	23	4	22	16
11	Frankfurt	27	31	19	14	11	24	30	19	25	25
12	Geneva	2	17	4	4	2	2	10	3	5	2
13	Hanoi	41	44	42	45	35	40	44	43	43	44
14	Ho Chi Minh	42	45	44	36	45	42	43	45	45	44
15	Hong Kong	6	16	32	21	23	31	25	33	24	34
16	Honolulu	35	22	21	26	33	21	6	21	16	6
17	Houston	37	18	35	35	34	15	3	8	13	6
18	Jakarta	40	42	39	40	43	41	40	42	41	41
19	Kuala Lumpur	44	28	43	42	44	43	41	40	39	42
20	London	31	4	22	16	7	10	20	11	23	22
21	Los Angeles	16	7	2	2	5	6	1	5	4	23
22	Madrid	29	37	24	22	18	28	29	30	36	28
23	Manila	39	43	37	41	38	37	37	39	40	39
24	Melbourne	14	1	27	28	20	7	19	7	17	17
25	Miami	36	27	29	29	30	17	11	15	10	5

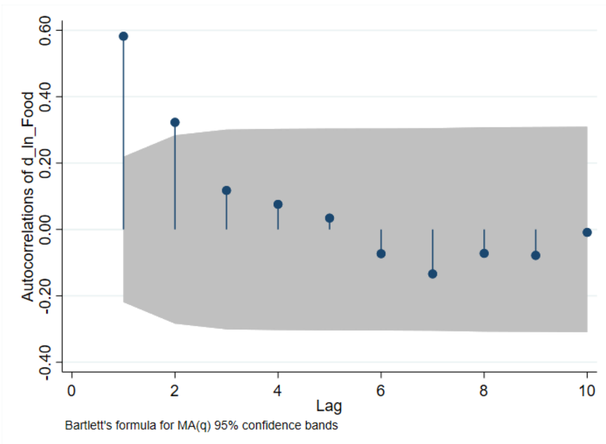
Table A.9: Cost of Living Rankings by Category for Ordinary Residents (continued)

No.	City	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
26	Milan	23	32	18	19	14	30	27	28	33	26
27	Minneapolis	24	12	17	33	22	11	12	25	6	6
28	Mumbai	45	29	45	44	42	44	45	44	44	43
29	Osaka / Kobe	26	41	31	43	31	33	32	32	37	32
30	Paris	21	15	15	15	12	25	31	22	30	27
31	Pittsburgh	30	24	14	37	26	19	4	18	14	6
32	San Francisco	12	9	33	5	13	18	7	9	11	6
33	Seattle	25	20	23	12	15	5	2	17	9	6
34	Seoul	3	36	10	27	32	34	33	31	27	30
35	Shanghai	34	38	25	24	39	35	36	37	31	35
36	Shenzhen	17	30	11	32	36	39	39	38	29	36
37	Singapore	13	3	30	23	1	29	24	34	28	31
38	Sydney	9	2	28	7	16	12	16	20	19	17
39	Taipei	22	35	38	34	37	36	38	36	38	38
40	Tel Aviv	5	6	9	6	9	9	17	6	26	19
41	Tokyo	7	40	34	8	29	32	35	27	35	32
42	Toronto	10	8	13	10	21	20	22	24	21	20
43	Vienna	19	34	12	11	8	26	21	10	18	24
44	Washington Dc	28	13	3	20	25	14	18	14	1	6
45	Zurich	1	10	5	3	6	3	8	1	2	1

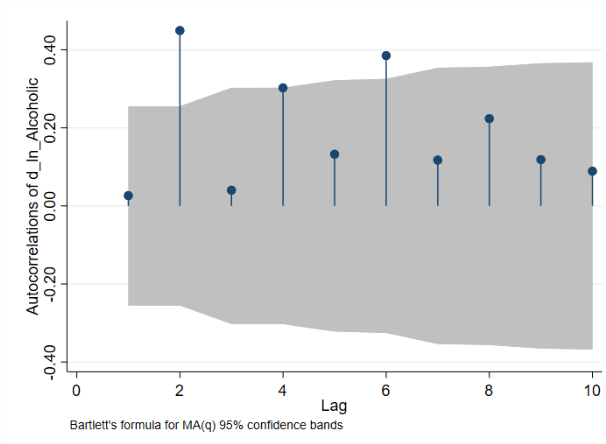
Notes: This table shows the cost of living rankings by category for ordinary residents among 45 major countries. Based on the consumption basket proposed by ACI , the ten categories are: (1) *Food and Non-Alcoholic Beverages*, (2) *Alcohol and Tobacco*, (3) *Clothing and Footwear*, (4) *Housing Rents and Utilities*, (5) *Household Supplies and Domestic Help*, (6) *Health*, (7) *Transport*, (8) *Recreation*, (9) *Education*, and (10) *Miscellaneous Goods and Services*.
Source: Asia Competitiveness Institute

Figures

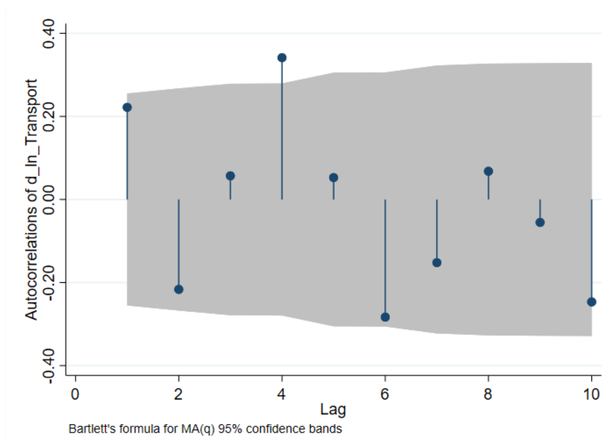
Figure 1: Autocorrelations



(a) Food and Non-Alcoholic Beverages



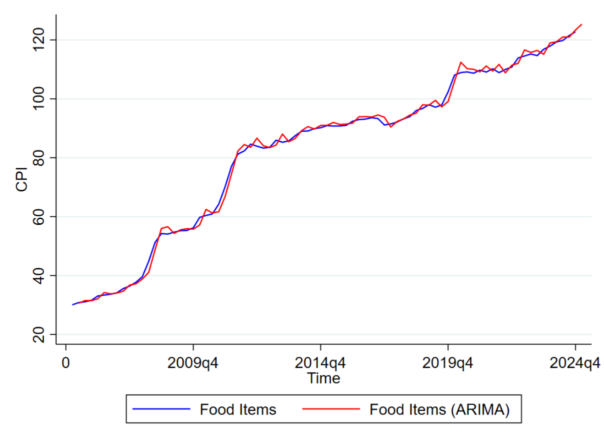
(b) Alcohol and Tobacco



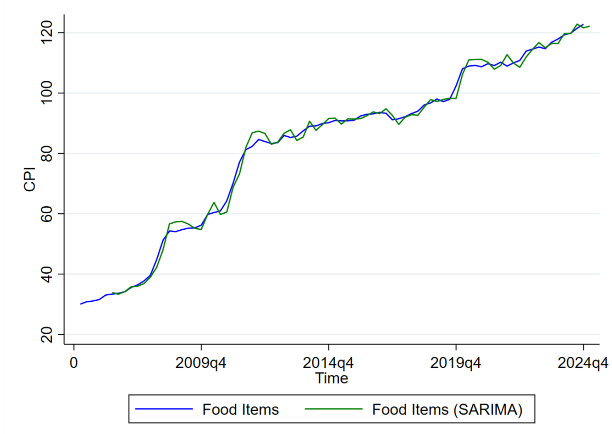
(c) Transport

Note: This figure plots the autocorrelations of the first difference of the logarithms of the CPI for *Food and Non-Alcoholic Beverages*, *Alcohol and Tobacco*, and *Transport* in the United States. The gray band is the 95% confidence interval.

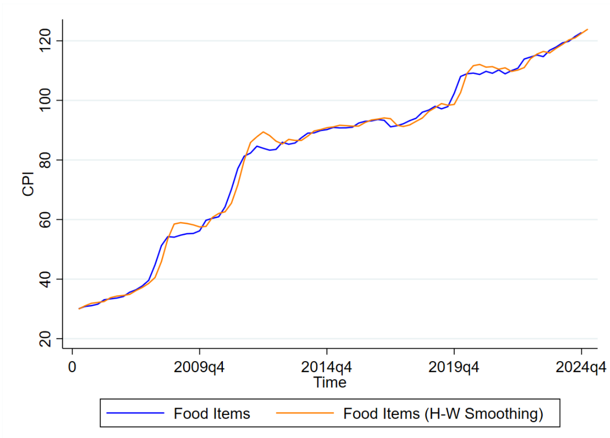
Figure 2: Consumer Price Index of Food and Non-Alcoholic Beverages in the United States



(a) ARIMA(1,1,0)



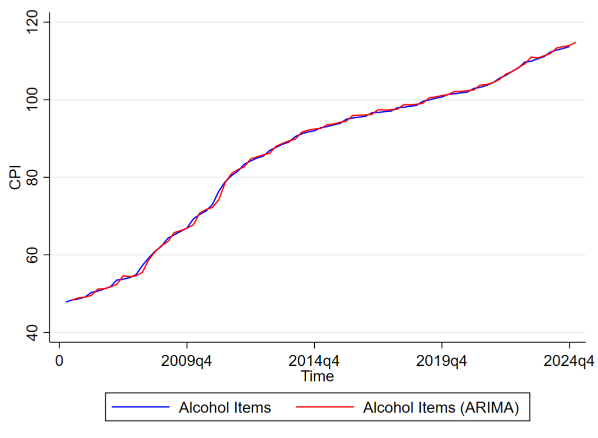
(b) SARIMA(1,1,0) × (1,1,0,4)



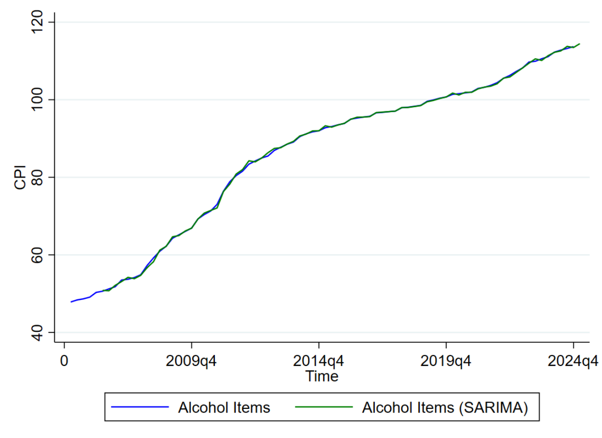
(c) H-W Smoothing

Note: This figure shows the CPI for *Food and Non-Alcoholic Beverages* in the United States. In figure (a), the blue line represents the observed values and the red line represents the values predicted by the ARIMA model. In figure (b), the green line represents the SARIMA model predictions, and in figure (c), the orange line represents the Holt-Winters Smoothing model predictions.

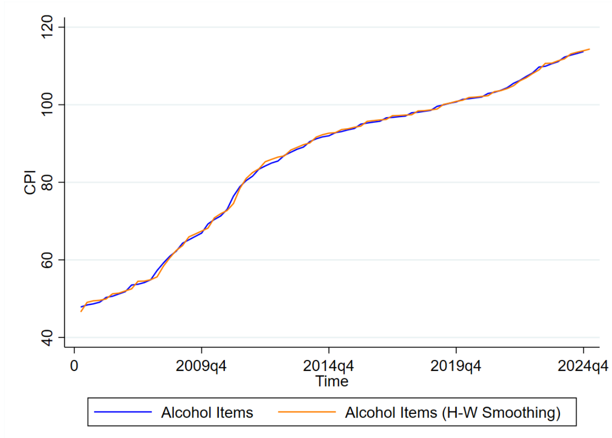
Figure 3: Consumer Price Index of Alcohol and Tobacco in the United States



(a) ARIMA(2,1,0)



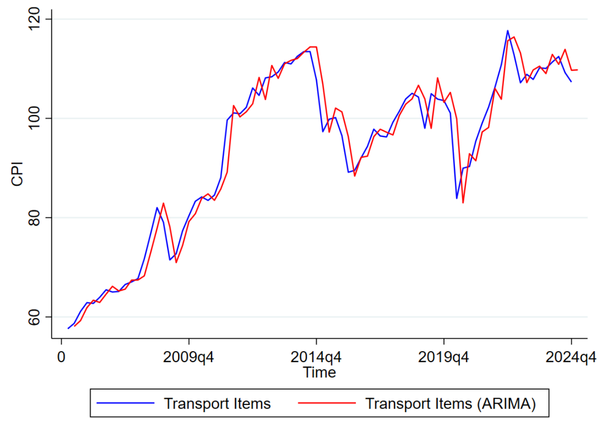
(b) SARIMA(2,1,0) × (1,1,0,4)



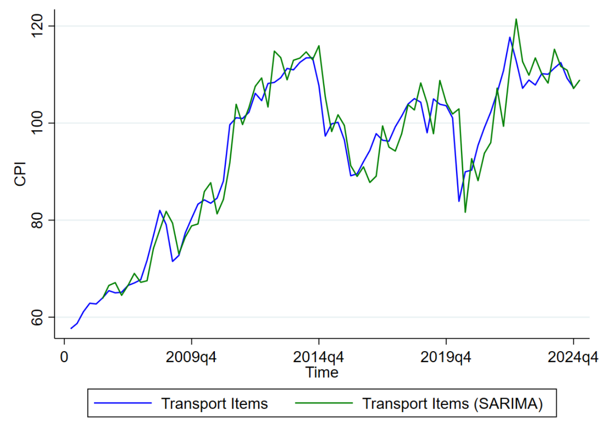
(c) H-W Smoothing

Note: This figure shows the CPI for *Alcohol and Tobacco* in the United States. In figure (a), the blue line represents the observed values and the red line represents the values predicted by the ARIMA model. In figure (b), the green line represents the SARIMA model predictions, and in figure (c), the orange line represents the Holt-Winters Smoothing model predictions.

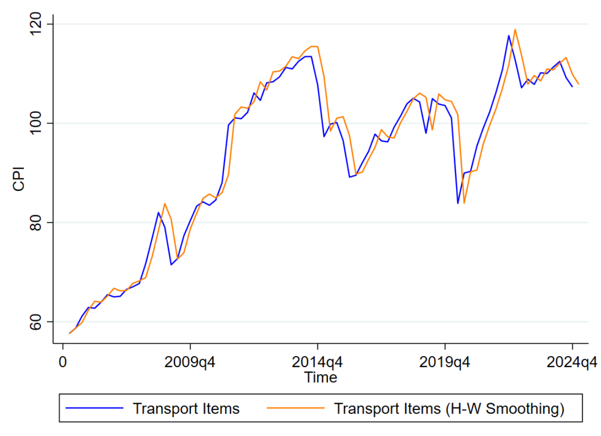
Figure 4: Consumer Price Index of Transport in the United States



(a) ARIMA(4,1,2)



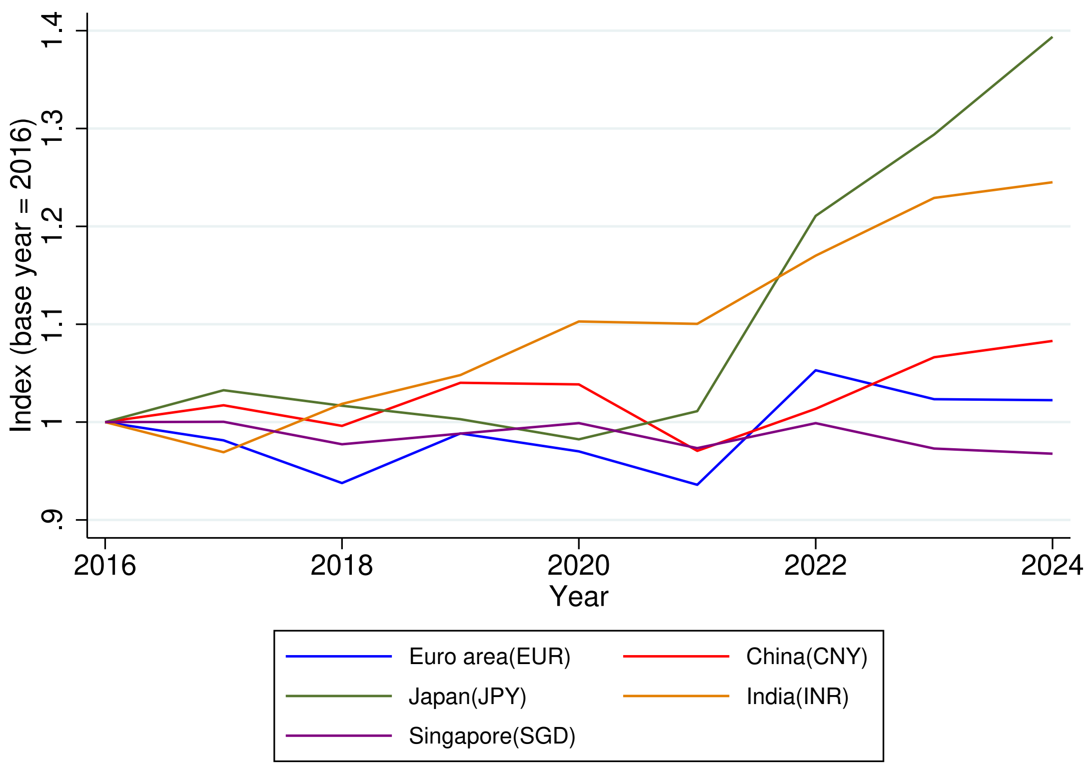
(b) SARIMA(4,1,2) × (1,1,0,4)



(c) H-W Smoothing

Notes: This figure shows the CPI for *Transport* in the United States. In figure (a), the blue line represents the observed values and the red line represents the values predicted by the ARIMA model. In figure (b), the green line represents the SARIMA model predictions, and in figure (c), the orange line represents the Holt-Winters Smoothing model predictions.

Figure 5: Bilateral Exchange Rates Relative to US Dollar in Nominal Terms



Notes: This figure plots the annual nominal value of one US dollar (USD) relative to the currencies of the Euro area, China, Japan, India ,and Singapore from 2016 to 2024, as the base year is 2016. A decrease (increase) indicates an appreciation (depreciation) of the respective currency against the USD.
Source: Bank for International Settlement (BIS)

Appendix A

SARIMA Model

A Seasonal ARIMA model can be used to reflect the seasonality part of the model. Specifically, a SARIMA$(p, d, q) \times (P, D, Q)_m$ model without constant can be expressed as:

$$\boldsymbol{\beta}(L^p)\boldsymbol{\beta_m}(L^P)\Delta^d\Delta_m^D y_t = \boldsymbol{\theta}(L^q)\boldsymbol{\theta_m}(L^P)\varepsilon_t \tag{A.1}$$

where

$$\begin{aligned}
\boldsymbol{\beta}(L^p) &= 1 - \beta_1 L - \beta_2 L^2 - \cdots - \beta_p L^p \\
\boldsymbol{\beta_m}(L^P) &= 1 - \beta_1^{'} L^m - \beta_2^{'} L^{2\cdot m} - \cdots - \beta_P^{'} L^{P\cdot m} \\
\boldsymbol{\theta}(L^q) &= 1 + \theta_1 L + \theta_2 L + \cdots + \theta_q L^q \\
\boldsymbol{\theta_m}(L^Q) &= 1 + \theta_1^{'} L^m + \theta_2^{'} L^{2\cdot m} + \cdots + \theta_Q^{'} L^{Q\cdot m}
\end{aligned}$$

Here, we have P seasonal autoregressive terms (with coefficients $\beta_1^{'}$, ...,$\beta_P^{'}$), Q seasonal moving average terms (with coefficients $\theta_1^{'}$, ...,$\theta_Q^{'}$). Moreover, $L^i y_t = y_{t-i}$, Δ^d applies the Δ operator d times, and similarly for Δ_m^D and D seasonal differencing based on m seasonal periods.

Rearranging Equation A.1, we have

$$(1 - \sum_{i=1}^{p} \beta_i L^i)(1 - \sum_{i=1}^{P} \beta_i^{'} L^{i\cdot m})\Delta^d\Delta_m^D y_t = (1 + \sum_{i=1}^{q} \theta_i L^i)(1 + \sum_{i=1}^{Q} \theta_i^{'} L^{i\cdot m})\varepsilon_t$$

which is equivalent to

$$\begin{aligned}
\tilde{y}_t = \beta_0 &+ (\sum_{i=1}^{p} \beta_i \tilde{y}_{t-i} + \sum_{i=1}^{P} \beta_i^{'} \tilde{y}_{t-i\cdot m} - \sum_{i=1}^{p}\sum_{k=1}^{P} \beta_i\beta_i^{'} \tilde{y}_{t-k\cdot m-i}) \\
&+ (\sum_{i=1}^{q} \theta_i \varepsilon_{t-i} + \sum_{i=1}^{Q} \theta_i^{'} \varepsilon_{t-i\cdot m} - \sum_{i=1}^{q}\sum_{k=1}^{Q} \theta_i\theta_i^{'} \varepsilon_{t-k\cdot m-i}) + \varepsilon_t
\end{aligned}$$

where β_0 is a constant term, and $\tilde{y}_t = \Delta^d\Delta_m^D y_t$. Typically, d and D will be 0 or 1, P and Q are less than 2, and m is 4 for quarterly and 12 for monthly data. Following the literature, we use a SARIMA model of order $(p, d, q) \times (1, 0, 1)_4$:

$$y_t = \beta_0 + \sum_{i=1}^{p} \beta_i y_{t-i} + \beta_1^{'} y_{t-4} - \sum_{i=1}^{p} \beta_i\beta_1^{'} y_{t-i-4} + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i} + \theta_1^{'} \varepsilon_{t-4} + \sum_{i=1}^{q} \theta_i\theta_1^{'} \varepsilon_{t-i-4} + \varepsilon_t \tag{A.2}$$

Holt–Winters Multiplicative Method

The component form for the multiplicative method is:

$$\begin{aligned}
\hat{y}_{t+h|t} &= (l_t + hb_t)s_{t+h-m(k+1)} \\
l_t &= \alpha \frac{y_t}{s_{t-m}} + (1-\alpha)(l_{t-1} + b_{t-1}) \\
b_t &= \beta(l_t - l_{t-1}) + (1-\beta)b_{t-1} \\
s_t &= \gamma \frac{y_t}{(l_{t-1} + b_{t-1})} + (1-\gamma)s_{t-m}
\end{aligned}$$

The error correction component is given by:

$$\begin{aligned}
l_t &= l_{t-1} + b_{t-1} + \alpha \frac{e_t}{s_{t-m}} \\
b_t &= \beta_{t-1} + \alpha\beta \frac{e_t}{s_{t-m}} \\
s_t &= s_t + \gamma \frac{e_t}{l_{t-1} + b_{t-1}}
\end{aligned}$$

where $e_t = y_t - \hat{y}_{t|t-1} - y_t - (l_{t-1} + b_{t-1})s_{t-m}$ and the smoothing parameters are either set or chosen to minimize the in-sample sum-of-squared forecast errors.