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Budget Constraints, Price Shocks and Urban Rural Consumption Allocation: Cobb-Douglas Utility Framing for Food, Tobacco, Alcohol and Apparel

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Abstract. There is an obvious income gap between urban and rural residents in China; changes in income levels and commodity prices will jointly affect the distribution of household consumption budget and consumption structure. This paper takes food, tobacco, alcohol, and clothing as the research objects, constructs a Cobb-Douglas two-commodity consumption model based on utility maximization, and uses the statistical data of income and consumption expenditure of urban and rural residents from 2021 to 2025 to calibrate the preference parameters of the model, and sets up three scenarios of benchmark, income increase, and food price rise for analysis. The results show that both urban rural income and target category consumption generally grow. Rural residents witness faster consumption growth yet remain at lower absolute consumption levels. Rural households persistently allocate a larger budget share to food tobacco alcohol, with these two basic goods accounting for a higher proportion of their disposable income. Simulation suggests that income growth expands the consumption budget proportionally and lifts real consumption of both goods without changing budget shares. Given a fixed total budget, rising food tobacco alcohol prices reduce real consumption while leaving clothing consumption unaffected. This paper provides modeling insights for interpreting urban rural consumption disparities.

Keywords: budget constraints, price shocks, urban rural consumption allocation

1. Introduction

Clothing, food, housing, and transportation represent major components of daily household expenditure. Under limited income, growth in one spending item reduces the budget available for others, while commodity prices determine the quantity of goods that can be purchased. Resident consumption concerns not only total spending volume but also spending allocation and actual goods obtained. Consumer choice theory explains household consumption arrangements from the dimensions of budget, price, and demand. According to data from the National Bureau of Statistics, China's per capita disposable income reached 43377 yuan in 2025, with 56502 yuan for urban residents and 24456 yuan for rural residents. A prominent urban rural income gap shapes household consumption capacity and budget allocation patterns, which cannot be fully interpreted merely by

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aggregate income and thus calls for analysis of specific consumption categories. This study focuses on statistically classified expenditure on food, tobacco, alcohol, and clothing, two essential living spending items. Using per capita data for urban and rural groups, it compares consumption distribution under identical budget frameworks. It addresses two core questions: the changing features of urban rural spending on food tobacco alcohol and clothing during 2021 2025, and how income growth or food tobacco alcohol price hikes influence the two consumption categories under given budget shares.

Consumer demand research usually puts income, commodity prices, and budget constraints in the same framework. A linear expenditure system separates basic consumption from budgets other than basic consumption, and can be used to analyze all kinds of consumer demand [1]. A near ideal demand system enables the share of commodity budget to change with price and total expenditure [2]. These demand systems can study multiple consumption categories at the same time and are widely used in the analysis of household consumption structure. Domestic studies often adopt such demand systems to compare urban and rural consumption. Relevant research applies the demand system to study the household expenditure structure of urban and rural residents in China, and finds that basic consumption items such as food and clothing have strong characteristics of necessities in urban and rural household consumption [3]. Some research incorporates the urban rural income gap into the LA/AIDS model and adopts provincial panel data to analyze how the income gap influences consumption structure [4]. Research carried out from the perspective of the urban rural consumption gap finds that the urban rural income gap, together with circulation conditions, would shape residents' consumption disparity [5]. The ELES model is adopted to investigate urban rural consumption structure in Yangzhou and calculate income elasticity for various consumption items [6]. Studies explore the effect of income changes on rural residents' consumption structure, and the results indicate that diverse income sources exert differentiated influences on rural residents' consumption level and composition [7]. Analysis conducted from the food consumption perspective verifies that the income gap would affect rural households' food consumption level and consumption choices [8]. Research examines rural residents' consumption based on basic public services and social equity, and identifies consumption heterogeneity among rural residents across regions [9]. Studies make a distinction between agricultural and non-agricultural income, and investigate how varied income sources affect household consumption expenditure and consumption disparity in rural China, proving that income level and its sources are critical factors for household consumption research [10].

The studies show that income level, urban and rural differences, and commodity categories all affect consumption structure, and also provide a reference for the selection of urban and rural data in this paper. Compared with the multi-commodity demand system, the Cobb-Douglas model has fewer variables, and the budget share and optimal consumption can be calculated directly. For course papers based on theoretical application, this method is easier to show the role of income constraints and price changes. In this paper, food, tobacco, alcohol, and clothing are regarded as two kinds of comprehensive commodities, first comparing the actual expenditure, and then analyzing the income and price scenarios. This paper focuses on the calculation process of the model and the difference between urban and rural results. The analysis will write utility functions and budget constraints based on consumer choice theory, and find the optimal consumption of food, tobacco, alcohol, and clothing. Collate the income and expenditure data of urban and rural residents from 2021 to 2025, and calculate the budget share of two types of commodities, food, tobacco, and alcohol, as well as the proportion of two types of expenditure in income. Using the actual data of 2025 to calibrate the preference parameters, there are three situations: a comparison benchmark, an

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income increase of 10%, and a food price increase of 10%. This paper discusses the impact of income and price shocks on consumption distribution through scenario analysis.

2. Basic theory

Y represents per capita disposable income, f represents per capita expenditure on food, tobacco, and alcohol, and C represents per capita expenditure on clothing. M=F+C represents the budget allocated to these two categories of goods. Because residents also pay for housing, transportation, medical care, education, and other expenses, M is only part of disposable income Y, so there is M≤Y. Y-M can be used for other consumption or savings. After this treatment, income Y reflects the overall affordability of residents, while budget M directly determines the amount that can be allocated to the two types of commodities in the model. In the theoretical model, qF and qC represent the consumption index of food, tobacco, alcohol, and clothing, respectively, while pF and pC represent the price index of the two categories of commodities, respectively. Both categories of statistics contain a variety of specific commodities, so qF and qC are expressed in the composite consumption index. In the benchmark case, pF and pC are set to 1, and a unit of expenditure corresponds to a unit of consumption index. For example, when the expenditure on food, tobacco, and alcohol is 10155 yuan, the benchmark consumption index is also recorded as 10155. After the price index increases, the consumption corresponding to the same amount will decrease. In the two-commodity framework, residents need to consider both their preferences and their budgets. If more attention is paid to food, tobacco, and alcohol, a higher proportion of M will be allocated to food, tobacco, and alcohol. Greater preference for apparel raises the budget share allocated to clothing. Residents choose qF and qC in budget m to maximize utility, as shown in model (1) and budget constraint (2):

$$\max U = qF^{Z} \times qC^{1-Z} \tag{1}$$

$$pF \times qF + pC \times qC = M,\ M \leq Y \tag{2}$$

Set qF>0, qC>0, pF>0, pC>0, and 0<Z<1. Z represents the weight of food, tobacco, and alcohol in the budgets of two categories of commodities, and 1-Z represents the weight of clothing. The greater Z, the higher the relative importance of food, tobacco, and alcohol in the utility function under the same other conditions. By solving the Cobb-Douglas utility function, the optimal consumption of two types of goods can be obtained. Therefore, the optimal nominal expenditure on food, tobacco, and alcohol is pF×qF*=Z×M; the optimal nominal expenditure on clothing is pC×qC*=(1-Z)×M. After Z is determined, food, tobacco, and alcohol use the budget share of Z, and clothing uses the budget share of 1-z ratio. When M increases, the amount of the two categories of goods will increase together; When the price of a commodity rises, the number of goods that can be bought decreases. The latter three scenarios are calculated according to this relationship.

3. Date and modeling

The data are from the annual household income and consumption expenditure released by the National Bureau of Statistics (2022-2025). Per capita disposable income, food, tobacco, and alcohol expenditure, and clothing expenditure of urban and rural residents are used to calculate m and F/M.

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F/M represents the proportion of food, tobacco, and alcohol in the budgets of these two categories of goods, which can be used to compare the distribution differences between urban and rural residents in the two categories of expenditure. As shown in Table 1, from 2021 to 2025, the per capita disposable income of urban residents increased from 47412 yuan to 56502 yuan, an increase of about 19.17%; Rural residents increased from 18931 yuan to 24456 yuan, an increase of about 29.18%. During the same period, the budget for two categories of commodities for urban residents increased from 10521 yuan to 12096 yuan, an increase of about 14.97%; the budget for two categories of commodities for rural residents increased from 6059 yuan to 7431 yuan, an increase of about 22.64%. The income of rural residents and the expenditure of both categories are growing faster, but the absolute amount in 2025 is still lower than that of urban residents.

Table 1. Disposable income of urban and rural residents and consumption budget

Region	years	Y (Disposable income)	F (Food and tobacco)	C(Clothing)	M=F+C	F/M(%)
City	2021	47412	8678	1843	10521	82.48
City	2022	49283	8958	1735	10693	83.77
City	2023	51821	9495	1880	11375	83.47
City	2024	54188	9957	1913	11870	83.88
City	2025	56502	10155	1941	12096	83.95
Rural	2021	18931	5200	859	6059	85.82
Rural	2022	20133	5485	864	6349	86.39
Rural	2023	21691	5880	921	6801	86.46
Rural	2024	23119	6226	966	7192	86.57
Rural	2025	24456	6434	997	7431	86.58

The expenditure on food, tobacco and alcohol for urban residents increased from 8678 yuan to 10155 yuan, and the expenditure on clothing increased from 1843 yuan to 1941 yuan; The expenditure on food, tobacco and alcohol of rural residents increased from 5200 yuan to 6434 yuan, and the expenditure on clothing increased from 859 yuan to 997 yuan. The growth rate of food, tobacco, and alcohol expenditure in both groups was higher than that of clothing expenditure. The clothing expenditure of urban residents dropped from 1843 yuan to 1735 yuan in 2022, and then gradually rebounded in the next three years, which increased the urban f/m to 83.77% in 2022. Looking at the expenditure structure, the F/m of rural residents from 2021 to 2025 has been higher than that of urban residents, and the budget m of two types of commodities of urban residents in 2025 is 12096 yuan, of which food, tobacco and alcohol account for 83.95%; M of rural residents is 7431 yuan, of which food, tobacco and alcohol account for 86.58%. Rural residents have a higher share of the budget for food, tobacco and alcohol, and a relatively low share of clothing. A comparison between M and disposable income Y reveals the relative weight of the two expenditure categories within residents' income. In 2025, the M/y of urban residents was about 21.41%, and that of rural residents was about 30.39%; that is to say, food, tobacco, alcohol and clothing together used a higher proportion of disposable income of rural residents. This difference is related to urban and rural income levels, cost of living, and consumption habits.

This model uses the following settings: Residents only allocate budget M between food, tobacco, alcohol, and clothing, and other consumption does not enter the model. Representative urban

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residents and rural residents pursue utility maximization in their respective m, and 0<Z<1. Let pF=pC=1; The price shock only raised the food price index pF from 1 to 1.1. Use 2025 F/M to calibrate Z, so urban residents Z=0.8395 and rural residents z=0.8658. In the income shock, it is assumed that budget m allocated to two categories of goods changes in proportion to disposable income y. Therefore, when y increases by 10%, m also increases by 10%, and the price and Z remain unchanged. This paper uses the actual data of 2025 to calibrate the preference parameters. The calculation of urban resident Z is 10155 ÷ 12096=0.8395, and the calculation of rural resident Z is 6434 ÷ 7431=0.8658. Accordingly, the clothing weight of urban residents is 0.1605, and that of rural residents is 0.1342. Both ZS are between 0 and 1, which meets the parameters of the Cobb-Douglas function and is consistent with the share of expenditure.

In terms of parameters, the weight of food, tobacco, and alcohol for rural residents is 0.0263 higher than that of urban residents, which corresponds to a difference of 2.63 percentage points between the two groups in 2025. Parameter calibration brings the real expenditure structure into the model, so that urban and rural residents retain their own budget characteristics under the same income or price changes. The latter calculation uses two separate parameters and does not combine urban and rural residents into a representative consumer. The benchmark scenario uses M and Z in 2025 and sets pf=pC=1. The income situation increases the disposable income of urban and rural residents by 10%, while increasing m by 10% according to the previous assumption. The price situation remained unchanged at M and Z, only raising the food, tobacco, and alcohol price index pf from 1 to 1.1. The three scenarios change only one major condition at a time, making it easy to observe the changes in income and price, respectively.

4. Empirical analysis

Table 2 lists the results for three scenarios. The unit of M is yuan/person; qF and qC are the consumption indices under the benchmark price, and one decimal place is reserved to facilitate the comparison of changes between each situation and the benchmark value. In the benchmark case, pF=pC=1. qF*=10155 and qC*=1941 for urban residents, Rural residents qF*=6434, qC*=997. The benchmark situation can reproduce two kinds of expenditure structures according to the structure. The consumption index of two types of commodities of urban residents is higher than that of rural residents, with a difference of 3721 in food, tobacco, and alcohol and 944 in clothing. This corresponds to the difference in the total budget of the two groups of residents.

Table 2. Simulation results of optimal consumption of food, tobacco, alcohol, and clothing

Region	Situation	M	pF	pC	qF*	qC*
City	Benchmark	12096.0	1.00	1.00	10155.0	1941.0
City	Income up 10%	13305.6	1.00	1.00	11170.5	2135.1
City	Food prices rise 10%	12096.0	1.10	1.00	9231.8	1941.0
Rural	Benchmark	7431.0	1.00	1.00	6434.0	997.0
Rural	income up 10%	8174.1	1.00	1.00	7077.4	1096.7
Rural	Food prices rise 10%	7431.0	1.10	1.00	5849.1	997.0

Assuming M varies proportionally with Y, a 10 % income rise lifts urban residents' M from 12096 yuan to 13305.6 yuan and rural residents' M from 7431 yuan to 8174.1 yuan. With prices and preference parameter Z held constant, urban qF* rises to 11170.5 and qC* to 2135.1, while rural qF*

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increases to 7077.4 and qC* to 1096.7. Both categories of consumption grow by 10 % with stable budget shares. In absolute terms, urban qF* goes up by 1015.5 and qC* by 194.1, versus rural increments of 643.4 for qF* and 99.7 for qC*. Larger absolute gains for urban resident's stem from their higher baseline budget, though the growth rate stays identical at 10 % for both groups, proving consumption is positively proportional to M under fixed budget shares. More incremental budget flows to food, tobacco, and alcohol, governed by each group's Z value. Owing to rural residents' higher Z, food related goods capture a slightly larger fraction of the additional budget.

Under the food price shock scenario, pF rises from 1 to 1.1 whereas pC, M and Z stay unchanged. Food tobacco alcohol consumption equals its baseline value divided by 1.1, bringing urban qF* down to 9231.8 and rural qF* to 5849.1, representing a uniform 9.09 % drop across groups. Clothing consumption qC* remains unchanged given stable clothing prices and budgets. Urban qF* registers an absolute reduction of 923.2 against 584.9 for rural residents; such a gap originates from urban households' higher baseline food consumption, while the shared decline rate comes from the same price increment. Mathematically, the 10 % price increase yields a 9.09 % quantity reduction. Nominal spending obeys fixed share rules, yet real food consumption shrinks. This outcome demonstrates how price hikes erode purchasing power. Income and price influence consumption via distinct channels: income expands the total budget for subsequent allocation, whereas price variation alters real consumption under a constant budget, reflecting separate roles of M and pF.

5. Conclusion

Based on the data of the National Bureau of Statistics from 2021 to 2025, this paper collates the expenditure on food, tobacco, alcohol, and clothing of urban and rural residents, and establishes a Cobb-Douglas two-commodity model. Data comparison shows that in the past five years, the income and expenditure of urban and rural residents have generally increased, and the growth rate of rural residents is faster, but the absolute amount of income and expenditure in 2025 is still lower than that of urban residents. In terms of expenditure structure, the proportion of food, tobacco and alcohol expenditure of rural residents in the budgets of food, tobacco and alcohol and clothing has been higher than that of urban residents for five consecutive years. These data show that the two basic living expenses account for a higher proportion of rural residents' income. Model calculations yielded two main results. When income increased by 10% and m increased by 10%, food, tobacco, alcohol, and clothing consumption increased by 10%; When food prices increased by 10% and the budget remained unchanged, food, tobacco, and alcohol consumption decreased by about 9.09%, and clothing consumption remained unchanged. Income changes mainly expand the scale of consumption of two categories of goods, while price changes change the actual amount that can be purchased under a given budget. Although the initial budget and weight of urban and rural residents are different, they have the same percentage response under the same model conditions.

The main contribution of this paper is to use the Cobb-Douglas two-commodity utility model to calibrate the preference parameters combined with the actual consumption data of urban and rural areas, and to intuitively quantify the impact of income changes and food price shocks on the optimal consumption of two basic consumer goods by grouping scenario simulation. This paper is conducive to understanding the logic of consumption distribution of urban and rural residents under budget constraints, and clearly shows the differentiated effect of income and price channels on consumption. There are some limitations in this paper's research, such as the model only includes food, tobacco, alcohol, and clothing, does not cover other important consumption items such as housing, medical treatment, and education, and is difficult to fully describe the overall consumption structure of residents. Future research may expand commodity categories, construct a multi

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commodity demand model, further investigate substitution and complementarity across consumption categories under external shocks, and capture urban rural residents' actual consumption decisions in a more comprehensive manner.

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