



# Research on Price Stickiness of Consumer Goods Based on Real-Time Social Information Flow

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**Abstract.** Due to the lack of consumer goods characteristics in the construction of the evaluation index of consumer goods price stickiness level, the loss aversion rate of consumer goods decreases. Therefore, based on the real-time social information flow of consumer goods price stickiness research. Through the real-time social information flow to adjust the price stickiness of consumer goods, through the study of the existence of price stickiness, we analyze the price stickiness data of consumer goods. Based on the characteristics of consumer goods, the index of product price stickiness level is established. The price adjustment frequency in the data period is calculated to determine the price stickiness of consumer goods. The range and absolute value of commodity prices are determined to adjust the price stickiness tendency of consumer goods. The experimental results show that the price stickiness is negatively correlated with the price adjustment cycle, and the effect of price stickiness adjustment based on real-time social information flow is better.

**Keywords:** Real-time social information flow · Consumer goods · Price stickiness

## 1 Introduction

Manufacturers can achieve equilibrium in the product market through their flexible pricing strategies [1]. However, in the real market economy, the adjustment of product price is often slow, which makes the price of the manufacturer can not keep up with the rhythm of the market environment, so that the equilibrium state can not be realized immediately. In order to explain this phenomenon, researchers begin to add price rigidity theory into Keynesian macroscopical theory, but there are some defects in the microcosmic explanation. Neo-Keynesian economists began to put forward relative wage theory, menu cost theory and approximation theory, and applied these theories to analyze the causes of wage stickiness, and emphasized the ability of Keynesian theory to analyze price rigidity from a microscopic perspective. Neoclassicism and Neo- Keynesianism have many differences in the study of the impact of price on the overall welfare level of a society. Reference [2] proposes to interpret the complexity of the competition in the consumer

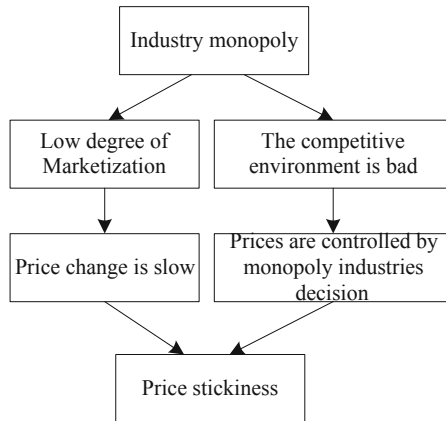
goods market – a complex Hilbert PCA analysis. Today's consumer goods market is developing rapidly, and the number of information media and competitive products is increasing significantly. In this environment, the quantitative grasp of heterogeneous interaction between enterprises and customers has aroused the interest of management scientists and economists, which requires the analysis of very high dimensional data. The existing quantitative research methods can not deal with such data without any reliable prior knowledge or strong assumptions. In addition, a complex Hilbert principal component analysis (chpca) method is proposed, and a synchronization network is constructed by Hodge decomposition. Significant motion with time lead/delay can be extracted from the data, and Hodge decomposition is helpful to identify the time structure of correlation. This method is applied to the Japanese beer market data, and reveals the changes of related variables in the selection process of consumers in a variety of products. In addition, significant customer heterogeneity is found by calculating the coordinates of each customer in the space from chpca results. Reference [3] proposed the characteristics and environmental value proposition of fast moving consumer goods reuse model. Fast moving consumer goods (FMCG) refers to the products that are often purchased and consumed in order to meet the continuous needs of consumers. In the online economy, fast moving consumer goods are usually disposable products. Product design limitations, inadequate collection systems and inefficient recycling processes prevent high recovery rates. The purpose of the study is to develop a comprehensive feature reuse model and evaluate its potential environmental value. 92 kinds of reusable products are selected for analysis to determine the reusable system elements. The analysis identified a framework of five reuse models and evaluated them to establish their environmental value compared with traditional disposable and disposable FMCG. Currently, consumers can access five reuse models and choose between exclusive and sequential reuse behaviors. When combined with recycling, recycling mode can make FMCG more effective consumption. Providing the infrastructure needed to support reuse and recycling is the key to successful and sustainable deployment of reuse models. However, according to the theoretical research of the literature, the similarities between them lie in the fact that they both believe that there is correlation between price changes and social welfare level, and that price adjustment plays a vital role in the change of welfare level. Based on the real-time social information flow, this paper proposes a research on the price stickiness of consumer goods. The frequency of price adjustments during the data period is calculated to determine the price stickiness of consumer goods. The range and absolute value of commodity prices determine the adjustment trend of the price stickiness of consumer goods. The proposed price stickiness of consumer goods has a good adjustment effect, which is not only the basis to solve the real macroeconomic problems, but also the theoretical basis for the government to deal with the economic shocks.

## **2 Price Stickiness Adjustment of Consumer Goods Based on Real-Time Social Information Flow**

### **2.1 Analysis of Consumer Price Stickiness Data**

Before studying the price stickiness data of consumer goods, it is necessary to verify the existence of price stickiness. According to the classification of different goods,

the prices of some goods change more frequently, and manufacturers of such goods often change their prices, while the prices of some goods change more slowly, or even remain unchanged for a period of time [4]. These goods because of their own special attributes or macroeconomic environment and other reasons, leading to manufacturers will deliberately manage the price of such goods, control its price change rate. At this point, the product price becomes sticky, as shown in Fig. 1.



**Fig. 1.** Generation of price viscosity

Product price stickiness analysis based on data provides more microscopic data in line with the actual macro-economic model, and changes in product prices may occur frequently within a month. Therefore, price behaviors such as sales promotion that occur within a month cannot be taken into account, and when the time dimension of a month is taken as the time dimension, manufacturers are also likely to stop selling or stop production, which results in a relatively large measurement error [5, 6]. On the other hand, the time and money required to analyse such data is significant, which limits the analysis of such data [7]. Next may choose the supermarket to sell the data, the supermarket when sells can leave information and so on commodity name, price and quantity. The cost of purchasing the data is relatively high by paying a certain fee to the supermarket. This price data is accurate and in line with the current market price. However, the data sample only covers some products such as daily necessities, food products, tobacco and alcohol products, etc., but industrial consumer goods are not included. The data are all from a certain supermarket when analyzing the price data. Compared with other data analysis methods, the type of sample commodities is not representative, and cannot accurately reflect the trend of changes in manufacturer prices in the whole market environment. On the other hand, because the data of supermarket is usually weekly, there will be a big time error, and the supermarket will usually carry out many promotions at festivals or celebrations, showing that the price of a certain commodity has dropped sharply for a period of time, while the price of the commodity in the whole market may remain the same as the original price, which will result in a big measurement error. Finally, with the development of Internet sales platform and computer technology, in recent years,

scholars gradually choose network data to analyze web page price data automatically by setting up crawler software program. This kind of data usually enters Taobao, Jingdong and other online sales platforms at a certain time to obtain web page price data. Compared with the former two kinds of data, the cost of these data is lower, and the daily regular analysis data can observe the frequency of price change in a shorter period, reducing the late-stage measurement error. Second, the data contains more detailed information, including but not limited to the name, attributes, prices, etc., the most important is that each commodity has a fixed number, which facilitates the price tracking of goods. On the other hand, data samples are also incomplete, and for a small number of industrial consumer goods the price data cannot be accessed on the Web because online sales are not yet widespread [8]. With the development of E-commerce in recent years, the variety of goods sold on the Internet begins to increase greatly, which makes up for the lack of data sample breadth, but also makes the analysis of data more dependent on e-commerce sales. Data analysis needs to master a certain knowledge of computer programs, so that the late analysis work can be carried out smoothly, and data analysis and collection work in batches, unlimited time breadth limit. Thus completes to the resident expense price stickiness data analysis.

## 2.2 Establishing Evaluation Indexes for Price Stickiness Level of Products

By analyzing the price stickiness data of consumer goods, we get the evidence of establishing the evaluation index of price stickiness level. Evaluation indicators are constructed on the basis of data and are more representative in terms of practice testing [9]. The real time social information flow is used to calculate the price stickiness of various consumer goods in our country, and the price characteristics of consumer goods are discussed. The calculation steps are as follows: First, calculate the price adjustment frequency  $F_i$  for each product  $i$  sample time period, namely:

$$F_i = X/N \quad (1)$$

In the formula,  $X$  represents the times of price adjustment and  $N$  represents the specific sample period. Using the above expressions, we can get the price adjustment frequency of each product in the sample period, which is also an important index for the evaluation of product price viscosity. Furthermore, the median frequency of price adjustment of the products under the classification of each industry, including 19 secondary classification products classified according to the Resident Commodity Classification Standards of the National Bureau of Statistics, was calculated. Finally, the weighted median of price adjustment frequency for each category of products is calculated, and the result is used to represent the total price frequency of the product market. The evaluation index of price stickiness level can be constructed. Through the calculation of the product price adjustment frequency, the price viscosity measure is affected by the extreme abnormal value, which leads to the calculation error. The real-time social information flow is used to calculate the price stickiness. Firstly, the price adjustment frequency of each product is calculated, and secondly, the average of the price adjustment frequency of the products in the lower classification is calculated. Finally, the weighted average number of each product is calculated, and the total market price frequency is represented

by the result. At the same time, the method is used to calculate the price change cycle in order to serve as the product price viscosity change cycle. The specific formula is as follows:

$$D = -1/\ln(1 - F_i) \tag{2}$$

In the formula,  $D$  is the price change cycle,  $F_i$  is the price adjustment frequency of the product. It can be seen from the above expression that when  $F_i$  is larger, the price change cycle  $D$  will be smaller, and the price stickiness level of the product will be weaker. There is a negative correlation between  $F_i$  and  $D$ . In the monopolistic competition market, it is assumed that the product demand of the manufacturer in the  $t$  period is:

$$Y_{it} = D(P_{it}/p_t)^{-\theta} \tag{3}$$

In the formula,  $\theta$  stands for product demand elasticity;  $P_{it}$  stands for product price.  $p_t$  is the average price of the product cycle, and the total output level of the manufacturer is:

$$Y'_{it} = Y_{it} \left[ \int D^{(\theta-1)/\theta} di \right]^{\theta/(\theta-1)} \tag{4}$$

In the formula,  $di$  is the elasticity coefficient of the product, and the price level is:

$$p_t' = [Y'_{it} \int D^{(1-\theta)} di]^{1/(1-\theta)} \tag{5}$$

The firm's actual marginal cost depends on two factors: productivity shock  $X_{it}$  and overall output gap  $MC_{it}$ . In this case, the actual marginal cost can be expressed as follows:

$$MC_{it} = \delta X_{it} (Y'_{it}/p_t')^2 \tag{6}$$

In the formula,  $X_{it}$  represents the natural output rate under total factor information, and  $Y'_{it}$  represents the actual rigidity. When  $Y'_{it}$  is small enough, the output gap will be relatively small. The total demand is determined by the quantity equation, the total demand for nominal money  $M_t$  is expressed as follows:

$$M_t = P_t Y_{it} \tag{7}$$

To sum up, the profit function of an enterprise is:

$$\Delta M_t = \mu(1 - \rho) + \rho \Delta M_{t-1} + \varepsilon_t - t^2 \tag{8}$$

In this case,  $\mu$  is the exogenous variable,  $\rho$  is the rigidity factor,  $\Delta M_{t-1}$  is the profit amount of the last cycle,  $\varepsilon_t$  is the price coefficient of the cycle product,  $t$  is the generation time of the cycle profit, In the steady state, with the increase of productivity. However, according to the above analysis, the calculation results under the real-time social information flow will be affected by extreme outliers, so when the update probability is  $t$ , the company does not update the information of new macroeconomic conditions. In the case of  $2 = t$ , the company always updates new information in time, so the model can be simplified to full information model. At the same time, changing prices from previous levels can be costly for a manufacturer. Specifically, if the manufacturer realizes the price change in the cycle, it must pay the cost, which makes the pricing decision of the manufacturer depend on the government.

### 2.3 Estimation of Consumer Price Stickiness Based on Real-Time Social Information Flow

This paper uses real-time social information flow to calculate the price stickiness of all kinds of consumer goods in China, and discusses the price characteristics of consumer goods in China through the calculation results. First, calculate the price adjustment frequency  $F_i$  of each product  $i$  sample period

$$F_i = X / N \tag{9}$$

In the formula,  $X$  represents the number of product price adjustment, and  $N$  represents the specific sample period. Using the above expression, the price adjustment frequency of each product in the sample period can be obtained, which is also an important index for evaluating the price stickiness of products. In addition, we continue to work out the median price adjustment frequency of each industry’s sub level classified products, including 19 secondary classified products according to the National Bureau of statistics resident commodity classification standard. Finally, the weighted median of the price adjustment frequency of each large category of products is calculated, and the calculation result is used to represent the overall price frequency of the product market [10, 11].

### 2.4 Adjusting the Stickiness of Consumer Goods

According to the stickiness of the price of consumer goods, the price propensity shall be adjusted, that is, the direction of price change shall be adjusted, and the commodity prices may be divided into upward and downward tendencies according to the price rise and downward tendencies of the commodity prices as a whole [12]. For the calculation of commodity price propensity under the social information flow, the average price adjustment range of each commodity is obtained by first calculating the sum of each commodity price adjustment range and its absolute value in the sample period, and then dividing the sum of ranges by the total price adjustment frequency of the commodity in the sample period. Then, the prices of the secondary commodities are summed and averaged. Finally, the median adjustment range of the secondary commodities is used to replace the adjustment range of the primary commodities. Describe the ratio of the times of commodity price adjustment and reduction to the total times of commodity price change. According to the formula, the average price adjustment propensity of every second class is obtained, and the median value is obtained as the price propensity of the first class. Suppose that the price change index is  $I_{it}$ ,  $I_{it}^+$  represents the rising frequency of commodity price,  $I_{it}^-$  represents the falling frequency of commodity price, and the calculation formula of price adjustment tendency is as follows:

$$\begin{aligned}
 g_s^- &= \sum_t w_{it} I_{it}^- / \sum_t w_{it} (I_{it}^+ + I_{it}^-) \\
 g_s^+ &= \sum_t w_{it} I_{it}^+ / \sum_t w_{it} (I_{it}^+ + I_{it}^-)
 \end{aligned}
 \tag{10}$$

In the formula,  $g_s^+$  represents the rising tendency of price and  $g_s^-$  represents the declining tendency of price.  $w_{it}$  is the fluctuation value of cyclical commodity price. The calculation results of commodity price variation range under each classification are shown in Table 1:

**Table 1.** Sticky periodic changes of price of consumer goods

Category descend	Increase (%)	Descend (%)	Category	Increase (%)	Descend (%)
Grain	52.83	47.17	Cloth	61.03	38.07
Grease	73.93	26.06	Tobacco	54.92	45.08
Meat fowl	51.54	48.46	Liquor	65.23	34.77
Egg	41.82	58.18	Durable goods	65.67	34.33
Aquatic products	43.48	56.62	Consumable goods	66.10	33.90
Fresh vegetables	56.63	43.37	Service	53.24	46.67
Medical treatment	51.28	26.34	Transportation	73.66	70.63
Education	92.86	7.14	Communications	80.06	25.76
Others	68.62	25.76	Hydropower	74.24	16.67

From Table 1, it can see that there is a significant correlation between the price change under the social information flow and the macroeconomic data, which shows that the pricing behavior of firms will be affected by the social information flow, that is, the state-related pricing model exists under the special economic conditions of our country. On the one hand, there is a positive correlation between the change of price and each variable, which indicates that the inflation rate will have a positive effect on the change of the price of consumer goods to some extent. On the other hand, there is a negative correlation with the price change, that is, manufacturers reduce their own price adjustment speed when the price rises, thus increasing market price stickiness. When implementing the tightening policy, with the increase of the reserve requirement of the bank, the manufacturers slow down the adjustment of the price of their own products, and the stickiness of the product market increases. On the contrary, when the expansionary policy is implemented, the reserve that banks must pay will be reduced. Generally speaking, the prices of the three kinds of consumer goods will increase more than decrease, and the price of the three kinds of consumer goods will increase more than 50%, which indicates that the prices of the products in our country will increase. In the classification of the next level, the products of different attributes and categories show obvious differences. Under the classification of food commodities, the highest price rise tendency belongs to the commodities of grain, and its price tendency is 73.93%. Under the classification of service goods, the highest price increase tendency is education, and the price tendency is as high as 92.86%, but the price increase tendency of communication goods is only 29.37%. Under the classification of industrial consumer goods, the price increase tendency of daily consumer goods is the highest, except for clothing and durable

consumer goods, the price increase tendency of all other industrial consumer goods is higher than 60%. So far, the price stickiness of consumer goods based on real-time social information flow is adjusted.

### 3 Experimental Analysis

Through the contrast experiment, we compare the stickiness adjustment of consumer goods price based on real-time social information flow with the loss aversion rate of traditional methods 1 and 2.

For the study on the loss aversion rate of consumer goods, the selection of the data set is the same as the data used for the price stickiness measurement of consumer goods, and the monitoring data on commodity prices of residents in large and medium -sized cities nationwide issued by the Price Monitoring Center of the National Development and Reform Commission are used. The time reference dimension of the data set is measured by month, and a total of nine types of consumer goods are included, and the classification of these nine types of consumer goods is conducted by the method of the National Bureau of Statistics for the classification of consumer goods. According to the secondary classification standards, there are six types of food commodities and two types of service commodities, and the price data of food and service commodities are the average prices of commodities sold in the market, while the price of other categories of commodities is the representative data based on the expenses actually paid by consumers for enjoying the services. A regression model shall be established to conduct regression analysis on the factors affecting price changes. Suppose that the time of examining the micro data such as the frequency of price change is  $t$ , the correlation factor of inflation rate is  $C$ , the dummy variable of time factor in the equation is  $\varepsilon_t$ ,  $\beta_i$  is the frequency of price change, and  $A_i$  is the amount of spillover of consumer goods, taking this as a representative, the paper studies the time-varying law of price change and calculates the loss aversion rate  $g_t$  of consumer goods as follows:

$$g_t = C + \sum_{i=1}^{12} \beta_i A_i + \varepsilon_t \quad (11)$$

Secondly, the equation will make a distinction between the current period and the lag period. Finally, the conclusion is drawn by analyzing the regression coefficient of the loss aversion rate of consumer goods, and the correlation between price changes and various factors and the degree of correlation are discussed.

The calculation results of price adjustment frequency and period of three major categories of consumer goods and their sub categories are shown in Table 2.

According to the data in Table 2, we can get the index of stickiness level of product price through each period without frictional economy, so that firms can set product price and maximize profit. While obtaining and processing effective information, the manufacturer has to pay a certain commodity cost, that is, the cost of setting up the floating index of the product, which involves the cost of time and manpower. Infrequent information updates are combined with state-dependent pricing to update indicators with probability. Through the establishment of price stickiness level of consumer goods value indicators to complete the summary of real-time social information flow, thus completing the price stickiness estimation.

**Table 2.** Evaluation index of product price stickiness

Classification population	Weight	Frequency (%)	Cycle (month)
On the whole	100	32	2.6
Grain	37.3	88	0.5
Grease	4.0	32	2.6
Meat fowl	3.2	88	0.5
Egg	7.1	88	0.5
Aquatic products	0.8	92	0.4
Fresh vegetables	6.3	86	0.4
Fresh fruit	12.0	92	0.5
Tobacco	3.9	92	0.45
Liquor	27.0	90	0.5
Durable consumer goods	2.4	88	1.4
Daily consumables	4.8	92	0.7
Medical care	3.9	76	0.5
Transportation	11.1	88	0.4
Communications	4.8	94	5.2
Education	35.7	16	2.8
Rental and property services	7.9	30	7.8
Hydroelectric fuel service	6.3	12	11.9
Others	1.6	8	1.7

By studying the loss aversion rate of consumer goods, the traditional methods 1 and 2 are compared with the research methods in this paper. The experimental results are shown in Table 3.

**Table 3.** Comparison of loss aversion rate of consumer goods

Types of consumer goods	Traditional method 1 Loss aversion rate (%)	Traditional method 2 Loss avoidance rate (%)	This paper studies the method loss aversion rate (%)
Grain	13.41	22.06	52.43
Grease	12.95	29.17	43.75
Meat fowl	17.35	14.29	50.29

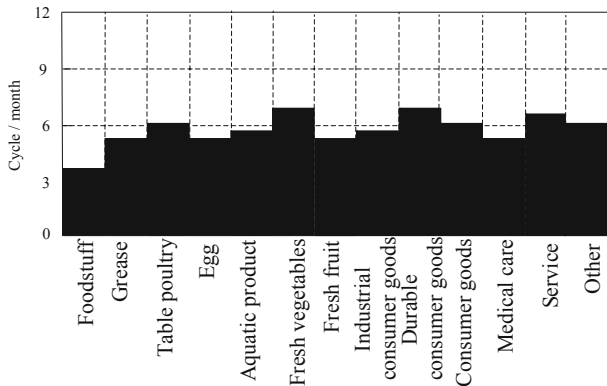
(continued)

**Table 3.** (continued)

Types of consumer goods	Traditional method 1 Loss aversion rate (%)	Traditional method 2 Loss avoidance rate (%)	This paper studies the method loss aversion rate (%)
Egg	13.36	16.31	52.86
Aquatic products	17.80	19.54	56.07
Fresh vegetables	15.95	29.22	47.52
Medical treatment	23.54	17.35	48.12
Education	13.21	24.66	42.01
Others	14.41	20.13	56.68

According to the data in the table, the traditional method 1 in consumer oil category loss avoidance rate was 12.95%, the highest in the medical category loss avoidance rate, 23.54%. Compared with the traditional method 1, the traditional method 2 has a higher rate of loss aversion of various consumer goods, and the lowest rate of loss aversion is 14.29%. Based on the real-time social information flow, the loss avoidance rate of consumer goods is 42.01% and 56.68%, respectively.

The overall price adjustment frequency of consumer goods is calculated to measure the overall cycle length of consumer goods, and the price stickiness and price change cycle of different categories of products show strong differences. In the secondary classification under the same classification, different products also show different price adjustment frequency. But to judge whether the price change has stickiness or not, under the premise of no consistent standard, the more common method is to draw the conclusion of price stickiness through comparison. When using the real-time social information flow to measure the price stickiness, we can get the price stickiness change cycle of various consumer goods, as shown in Fig. 2.



**Fig. 2.** Price stickiness cycle of consumer goods

From the cyclical results of the real-time social information flow in Fig. 2, we can see that the overall frequency of consumer goods price adjustment cycle implies that there is a monthly consumer goods price adjustment cycle. The result of the three-month price adjustment cycle for food products means that the number of monthly price changes in food accounted for 33.33%. A price adjustment period of 5.9 months for industrial consumables shall mean that the monthly price change of products accounts for 16.9% of the total price change of industrial consumables, among which the price stickiness of grain products is the lowest, and the adjustment period for daily consumables such as tobacco, alcohol, etc. is less than the overall price adjustment period for industrial consumables, and the price adjustment period for medical products is five months, which means that the monthly price change of products accounts for 20% of the total price change of medical services, compared with the price stickiness of services being the lowest, and the other prices are less than the overall price adjustment frequency for medical consumables. According to the cycle calculation results, the total cycle length of daily consumer goods is 6 months, which indicates that it takes 6 months for the consumer goods to realize a round of price change, and the price stickiness is negatively correlated with the price adjustment cycle. Therefore, the price stickiness of food and industrial consumer goods is shorter than that of service goods. By estimating the price stickiness of consumer goods, the adjustment tendency of price stickiness can be determined.

## 4 Conclusion

This paper summarizes the correlation between the general pricing mode and the state, and provides a reference for the formulation of monetary policy and the prediction of industry development trend. Price stickiness is negatively correlated with price adjustment cycle. The future discussion should gradually turn to empirical research based on market microscopic data. At the same time, we should pay more attention to the non-economic factors, such as cultural tradition, so as to fully and accurately understand the market operation mechanism of our country.

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