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SOLVING THE PUZZLE OF CHINA'S LOW INFLATION: A NEW PERSPECTIVE FROM SECTORAL CORE INFLATION FLUCTUATIONS

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Abstract. China's constantly rapid economic growth accompanying by a low overall inflation has long been mysterious in macroeconomics. The core purpose of this paper is to solve this puzzle. Therefore, we integrate overdetermined set of equations into a MUCSVO model to explore the volatility mechanism of the overall inflation from a sectoral perspective. Our key findings include: 1) the hedging effect of sectoral inflation fluctuations principally accounts for China's long-run stable overall inflation; 2) the main contradiction of China's inflation has been shifting from high price levels in the traditional food and residence categories to rising prices in the health care category; 3) as the proportions of inflation in the food and residence categories fall steadily, sectoral inflation weights become more evenly distributed. In conclusion, China's overall inflation and deflation will be much less likely to occur, while inflation is still of sectoral imbalance. Unusual price fluctuations in the food and health care categories, which are highly relevant to basic living standards of the low-income group, deserve close attention in particular. Overall, besides solving the puzzle of China's low inflation, our model is applicable to economies that do not publish inflation weights, which is a useful extension of core inflation measurement.

Keywords: sectoral core inflation, sectoral inflation weight, MUCSVO model augmented with overdetermined set of equations.

JEL Classification: C51, E31, E52.

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1. Introduction

Rapid economic growth coincides with high inflation in general (Cruz, 2022; Jiang et al., 2023). This is not the case in China though. China has once maintained high-speed economic growth in the early 21st century, while its overall inflation level has remained within an appropriate range meanwhile. This unusual phenomenon has been mysterious in macroeconomics for quite a long time (Carriero et al., 2022), which therefore forms the motivation of this paper aiming to solve the puzzle systematically. In fact, there are three scenarios contributing to an overall low inflation: 1) the government and monetary authority control the overall price level properly, hence there is no typical inflation indeed (Adam et al., 2022); 2) significant sectoral imbalance (i.e., rising prices in some sectors hedge falling prices in some other sectors)

leads to an overall stable inflation (Cristadoro et al., 2005; Giri, 2022); 3) instead of weighting sectoral inflation with reference to sectoral consumption share in calculating the consumer price index (CPI), the Bureau of Statistics may down-weight certain high-inflation sectors subjectively for polishing the data of overall inflation (Stock & Watson, 2020). According to the official data published by the National Bureau of Statistics (NBS) (stats.gov.cn), China's low inflation does not apply to the first scenario, as the nation has experienced typical local high inflation and even hyper-inflation over the past two decades. Taking late 2007-early 2008 for example, its annualized inflation in the food category is once up to 20%, not to mention that the year-on-year price of pork once exceeded 50%. In addition, high inflation with an average year-on-year growth rate of 7%–8% in the residence category has lasted over half a year in 2008. Thus, China's stable overall inflation is very likely to apply to either the second or third scenario. In order to explore the internal mechanism of China's stable overall inflation in the long run, it is necessary to monitor trending changes in sectoral inflation and the actual contribution of sectoral inflation to the overall inflation. However, few studies have addressed this in detail. It is mainly because China's inflation consists of eight consumption categories, while the NBS has never completely published the weight contribution of the corresponding eight sectors to the overall inflation. In consequence, we can only observe the overall CPI as well as sectoral CPI without sensing their logical relationship in essence, not mentioned to grasp core inflation trend from sectoral angle.

In fact, it is vital to estimate sectoral inflation trend reasonably, and thereby characterize the overall inflation from the perspective of sectoral weight (Stock & Watson, 2016). This is because a nation's inequality and income disparity will be exacerbated along with economic development. Thus, different income groups will pay closer attention to sectoral CPI fluctuations in the categories of their major consumption than to trending changes in the overall CPI (Kim & Lim, 2022; Giri, 2022). For example, Zheng et al. (2023) and Afonso and Sequeira (2023) propose that the low-income group is largely concerned with price fluctuations in the food category; the middle-income group pays closer attention to price fluctuations in the residence category; the high-income group focuses on price fluctuations in the categories of education and recreation to a greater extent. The situation is more complicated in China. For example, Shi et al. (2022) proposes that China's Gini index was up to 0.47 by 2021. The inequality of wealth distribution has been so serious that we should form a real opinion of China's inflation based on sectoral CPI. In terms of economic significance, it helps us to better understand the true hedging state of price fluctuations across consumption categories for solving the puzzle of China's low inflation. In terms of policy implication, properly monitoring sectoral inflation enables the government and monetary authority to develop a more comprehensive understanding of the real price level and which groups suffer from high inflation, especially when serious trending inflation takes place in the food category that is highly relevant to basic living standards of the low-income group. It promotes the government and monetary authority to respond (e.g., price control, material supply or voucher policy) and curb local abnormal price fluctuations swiftly for defending the interests of the low-income group.

To reflect the true state of sectoral inflation accurately and solve the puzzle of low inflation fundamentally, we innovatively develop a MUCSVO model augmented with overdetermined set of equations. The model can estimate not only sectoral inflation and the overall inflation but also the contribution of sectoral CPI to the overall price level. As an important extension

to the MUCSVO model proposed by Stock and Watson (2016), our augmented MUCSVO model is a generalized one. It is applicable to economies that do not publish inflation weights as well as China, which is a useful extension of core inflation measurement.

The contributions of this paper can be summarized as follows: 1) in terms of economic significance, we solve the puzzle of China's low inflation fundamentally. In fact, we find that inflation is still widespread in China, and mostly concentrating in the food, residence and health care categories that are all highly relevant to the low-income group. Given that the core characteristics of this group are relatively large population base and weak consumption power, it essentially determines that the sectoral inflation of these categories makes limited contribution to the overall inflation, but is sensitive to perceive by the public. In short, the illusion of China's low inflation is characterized by low-value indicator and sensitive public perception in essence. 2) In terms of research methodology, our core contribution is to propose a new approach to measuring core inflation, namely the MUCSVO model augmented with overdetermined set of equations. As an important extension to the MUCSVO model proposed by Stock and Watson (2016), our augmented MUCSVO model can estimate the weight of sectoral inflation to the overall inflation effectively. On the one hand, it solves the hierarchical estimation problem of core inflation utterly, especially for economies that do not publish sectoral inflation weights. On the other hand, even for economies that publish sectoral inflation weights such as the U.S., it is still meaningful that we can estimate sectoral inflation weights in comparison to the published counterparts so that to judge whether a nation's government or monetary authority intends to adjust sectoral inflation weights subjectively. 3) In terms of policy implication, we find that China's sectoral inflation weights become more evenly distributed, which suggests that it is less likely for individual sectoral price fluctuations to lead an overall inflation. Although the economic significance of monitoring the overall inflation has declined considerably, that of monitoring sectoral inflation becomes increasingly prominent in contrast, especially in categories that are highly relevant to the low- and middle-income groups. This is because these sectoral price fluctuations, which are the most direct sources of inflation perceived by the public, have a very wide public coverage. In fact, moderate inflation makes sense only if price levels in these categories remain within an appropriate range.

2. Literature review

Core inflation, which is an important branch of inflation research, refers to trending increases in price level (Eckstein, 1981; Richter et al., 2019; Bernanke, 2020; Hazell et al., 2022). Besides overcoming the shortcomings of excessively volatile and frequent fluctuations in headline inflation indicators such as the CPI, it thereby captures the long-term trending changes in price level (Forbes, 2019; Bolhuis et al., 2022; Giri, 2022), which offers a reasonable guidance for public expectations and reduction of monetary policy implementation costs. The remaining section will review the literature of core inflation measurement and application according to timeline.

Earlier studies concentrate on all kinds of filtering techniques used to remove the CPI's short-term volatility components and thereby obtain core inflation, which is also known as the single-indicator filtering method (Quah & Vahey, 1995; Matilla-Garcia, 2005; Fasanya &

Awodimila, 2020; Saboori-Deilami & Bashiri, 2021). For example, Hanif et al. (2020) eliminates the CPI's noise components using wavelet domain de-noising and thereby obtains Pakistan's monthly series of core inflation during 1992–2017. The authors propose that core inflation estimated by the method can desirably reflect the long-term trend of price fluctuations via forecasting accuracy analysis. Using maximal overlap discrete wavelet transform (MODWT), Saboori-Deilami and Bashiri (2021) estimates Iran's monthly series of core inflation, and proposes that core inflation indicators estimated by the method are superior to traditional wave filters in terms of persistence. However, the single-indicator filtering methods have a few inherited constraints: 1) the settings of wave filter parameter are subjective (Baxter & King, 1999; Fan et al., 2022); 2) the estimating results lack economic significance (Pincheira-Brown et al., 2019); 3) only the overall price fluctuations are reflected, while structural price changes are missing (Baqaee, 2010; Stock & Watson, 2020).

As a supplement to the single-indicator filtering method, the synthesis of multiple indicators based on the CPI components divides core inflation measurement into two steps: step 1 measures sectoral core inflation; step 2 estimates the overall core inflation by weighting sectoral core inflation. The method gradually becomes the mainstream of core inflation measurement thanks to strong economic significance and solid micro foundation (Stock & Watson, 2016, 2020; Carriero et al., 2020; Fan et al., 2022). For example, Elmer and Maag (2009) finds that the common factor of Switzerland's inflation system only accounts for less than 30% of the overall inflation during 1983–2008 using a dynamic factor model, which implies that it is infeasible to discover the sectoral imbalance and structural contraction of price system by observing the CPI solely. Ajello et al. (2020) and Fan et al. (2022) estimates the persistence of sectoral headline inflation using a dependence task scheduling model (DTSM) and autoregressive model, respectively. By considering persistence indicators to be weight and weighting sectoral CPI, they thereby obtain core inflation. It is shown that core inflation estimated by the synthesis of multiple indicators has a stronger capacity of capturing economic event as well as responding to monetary policy than the counterpart estimated by the single-indicator filtering method. Using machine learning model and Shapley decomposition, Aras and Lisboa (2022) states that machine learning will improve the estimation accuracy of core inflation system significantly. Although these studies have made great contributions to core inflation measurement, their applications will be subject to some rigorous constraints. That is, such structural models usually require data to be normally distributed, and will not be applicable when data is characterized by "leptokurtosis and fat-tail" and "volatility clustering" (Bermingham, 2010; Gamber et al., 2015; Sharma & Sahu, 2022).

To solve the problem of irregular data, Stock and Watson (2016) proposes a MUCSVO model based on the classical dynamic factor model. The model's largest advantage is able to identify and remove outliers for sectoral core inflation simulation, and to reduce the influence of irregular data to the greatest extent. The method has been widely promoted once it is proposed. For example, Manopimoke and Limjaroenrat (2017) develops Thailand's system of core inflation indicators using the MUCSVO method; besides measuring core inflation in the U.S. during 1999–2019, Fulton and Hubrich (2021) finds that the MUCSVO method possesses the strongest short-term forecasting ability and econometric stability. Using the MUCSVO

method, Kim and Lim (2022) proposes that there is a typical sectoral imbalance behind South Korea's overall stable core inflation, in which the sector of rental for housing faces severe deflation trend. Dixon et al. (2023) estimates core inflation in the U.K. using the MUCSVO method, and finds that the estimated core inflation has a robust feedback to monetary policy.

Nevertheless, the MUCSVO method is subject to several application constraints, such as the requirement of published sectoral core inflation weights (Mazumder, 2014; Chan et al., 2018; Fasanya & Awodimila, 2020). While the MUCSVO method is usually applicable to developed economies including the U.S., Western European countries and Japan, it fails to apply to the nations (e.g., developing economies including China and Brazil) that do not publish complete sectoral inflation weights (Hu & Zhang, 2021; Fan et al., 2022), which severely limits the application of the MUCSVO method. Thus, it is prerequisite to estimate sectoral inflation weights in order to precisely measuring core inflation in nations that do not publish them. This is both an urgent problem to solve in the field of core inflation research and the key question to answer in this paper.

The above literature review shows that existing studies of core inflation are relatively deep. Structural core inflation system has gradually become the most widely used mean for forecasting core inflation, thanks to its advantages such as strong economic significance and solid micro foundation. The method is particularly necessary for China at present, as China's overall trend of low inflation has always been mysterious in macroeconomics. The internal mechanism of fluctuations in China's inflation system will not be thoroughly understood unless figuring out the individual trend of sectoral inflation and contribution of sectoral inflation to the overall inflation. Hence, this paper proposes a MUCSVO model augmented with overdetermined set of equations. In addition to solving the puzzle of China's low inflation based on the estimation of sectoral core inflation weights, it provides a new way of thinking and direction for core inflation measurement.

3. Data and methodology

3.1. Data

Aiming to estimate core inflation using sectoral inflation, this paper uses basic data of the month-on-month growth rates of the CPI and eight sectoral inflation sourced from Statistics database of China Economic Network (db.cei.cn), with a sampling period of 2006M1–2020M12. The sampling period is set because China's CPI is a typical Laspeyres index. The NBS assigns (but does not publish) weights to sectoral inflation according to the shares of sectoral consumption in the overall consumption every five years, and thereby calculates the weighted overall CPI. It is worth noting that the NBS adjusts eight inflation categories in January 2016 slightly[1]. Thus, the description of the overall and sectoral CPI trends will be divided into two segments, 2006M1–2015M12 and 2016M1–2020M12. For simplicity, the base period

[1] The traditional eight inflation categories during 2006–2015 are: 1) Food, 2) Tobacco, Liquor and Articles, 3) Clothing, 4) Household, Facilities, Articles and Services, 5) Health Care and Personal Articles, 6) Transportation and Communication, 7) Recreation, Education and Culture Articles, and 8) Residence. The new eight inflation categories after 2016 are: 1) Food, Alcohol and Liquor, 2) Clothing, 3) Articles for Daily Use and Services, 4) Health Care, 5) Transport and Communication, 6) Education, Culture and Recreation, 7) Residence, and 8) Other Articles and Services.

of each segment is set to be the beginning period respectively (i.e., 2006M1 and 2016M1), and the base-period CPI is normalized to 1. Figure 1 depicts the month-on-month growth rates of the overall CPI and sectoral CPI, in which the LHS (RHS) figure has a base period of 2006M1 (2016M1).

First, inflation in most categories rises slowly, which is similar to the overall CPI trend. It shows that there is a significantly co-movement of upward trend among China's sectoral inflation. Secondly, sectoral inflation rates vary greatly across categories. During 2006–2015, price level in the food category rises much faster than that in other categories, while there is even a slight deflation in the category of household, facilities, articles and services. The category of health care has become the leader of sectoral inflation since 2015, while the category of food, alcohol & liquor no longer exhibits a typical trend of sectoral inflation meanwhile. It

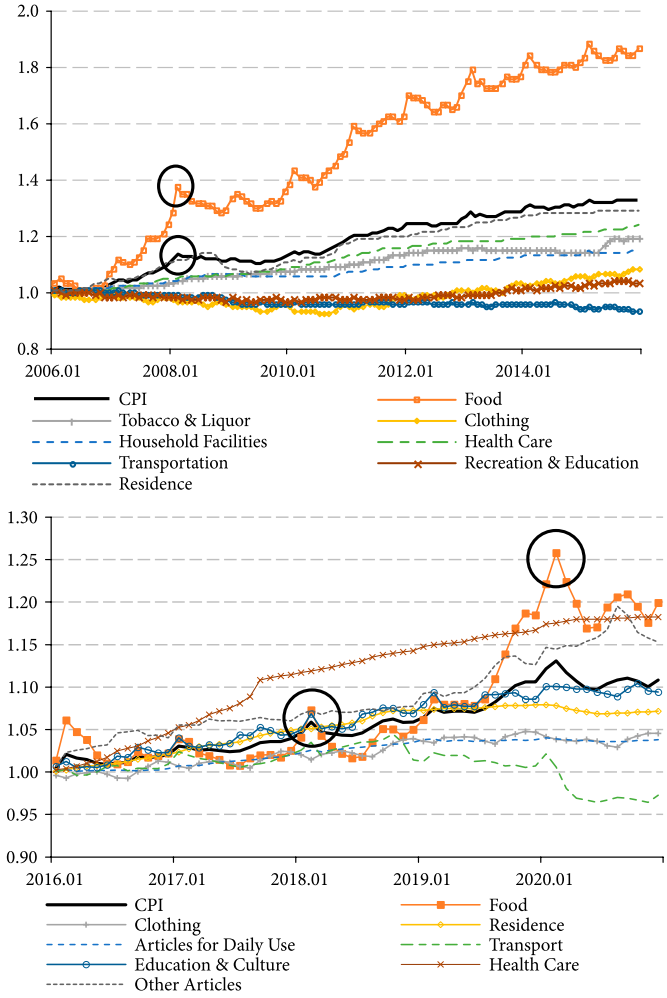

Figure 1. Month-on-month price indices of China's 8 traditional and 8 new categories

shows that there is a typical sectoral individual trend in China's inflation system too. Thirdly, both the overall CPI and sectoral CPI have experienced significant short-term fluctuations. In February 2020, the month-on-month growth rate of sectoral CPI in the food category is nearly 10% due to the COVID-19 pandemic expectation and China's Lunar New Year holiday, which pulls up the overall CPI by 2.6% meanwhile. In February 2016 and March 2018, the overall CPI also suffers from increased short-term fluctuations, which is not shaped by certain sectoral inflation but is characterized by obvious sectoral co-movement. It shows that each round of abnormal price fluctuations has its own formation condition and background, including the overall general trend and volatility as well as the sectoral individual trend and volatility. Therefore, monitoring China's inflation trend should not be limited to the overall CPI, but also to the individual trend and volatility of sectoral CPI. On the one hand, accurately capturing the trend of sectoral CPI helps different consumption groups to grasp price fluctuations. On the other hand, price levels across categories are very likely to have different trends. It suggests that accurately capturing the trend of sectoral CPI will not only solve the puzzle of China's low inflation, but also reveal the structural contradictions and real characteristics of China's inflation system. Its key economic significance allows us to identify which consumption groups are paying for high inflation actually.

After developing a general idea of China's inflation, we need further describe structural changes in household consumption expenditure. This is because reasonable sectoral weights should be consistent with household consumption expenditure shares. Comparing such empirical data with the subsequent estimated sectoral weights is helpful to examine the reasonability of weights assignment to various consumption categories by the NBS, and whether the institution has any intensions to polish data. Since the NBS does not publish sectoral household consumption expenditure shares of eight traditional categories, this paper only presents changes in sectoral household consumption expenditure shares of eight new categories as depicted in Figure 2. There are two trending characteristics: one is an obvious descending trend on the proportion of food consumption, the other is a slightly ascending trend on the proportion of residential consumption. All other sectoral household consumption expenditure shares are relatively stable. Thus, assigning fixed weights in each fixed base period will not

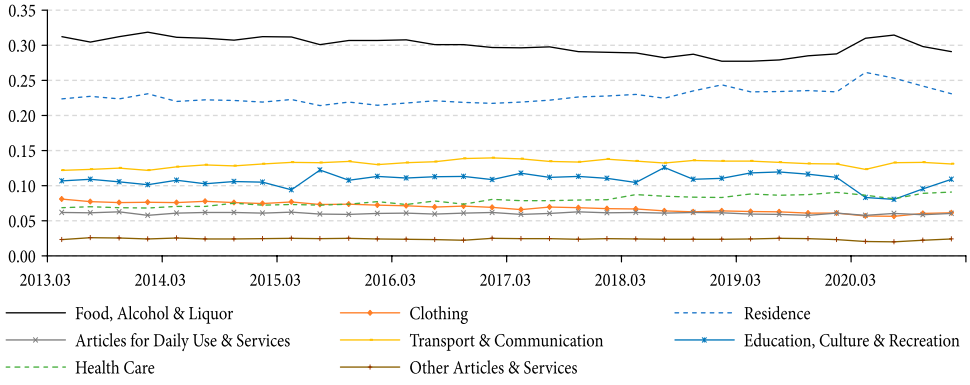

Figure 2. Changes in consumption proportion in the framework of the 8 new categories after 2013

cause significant structural impact. Additionally, according to some point-in-time data published by the NBS, the total sectoral household consumption expenditure shares of food and tobacco, liquor & articles is about 40%, and the share of residence is about 10%–15% in eight traditional categories, which significantly differs from the structure of sectoral household consumption expenditure at present. Thus, it is concluded that an effective set of weighting coefficients for assigning weights on sectoral inflation in the two segments should satisfy: the total sectoral household consumption expenditure shares of food and tobacco, liquor and articles in eight traditional categories is greater than its counterpart in eight new categories, while the share of residence in eight new categories is greater than its counterpart in eight traditional categories.

3.2. Methodology

First, the benchmark MUCSVO model is:

$$\pi_{i,t} = \alpha_{i,\tau,t}\tau_{c,t} + \alpha_{i,\varepsilon,t}\varepsilon_{c,t} + \tau_{i,t} + \varepsilon_{i,t}, \tag{1}$$

where subscript c denotes common component, subscript i(i = 1, ..., 8) denotes category whose inflation can be classified into four groups: common trend factor $\tau_{c,t}$, sectoral trend factor $\tau_{i,t}$ in category i, common temporary volatility $\varepsilon_{c,t}$, and sectoral temporary volatility $\varepsilon_{i,t}$ in category i. Influence coefficient $\alpha_{i,\tau,t}$ and $\alpha_{i,\varepsilon,t}$ denotes the influence of $\tau_{c,t}$ and $\varepsilon_{c,t}$ on sectoral inflation, respectively. Assume that the trending component τ_t and temporary volatility ε_t of headline inflation π_t both contain common factor following a time-varying process, $\tau_{c,t}$ and $\tau_{i,t}$ both follow a martingale process, and common temporary volatility $\varepsilon_{c,t}$ and sectoral temporary volatility $\varepsilon_{i,t}$ are not serially correlated:

$$\tau_{c,t} = \tau_{c,t-1} + \sigma_{\Delta\tau,c,t} \times \eta_{\tau,c,t}; \tag{2}$$

$$\varepsilon_{c,t} = \sigma_{\varepsilon,c,t} \times s_{c,t} \times \eta_{\varepsilon,c,t}; \tag{3}$$

$$\tau_{i,t} = \tau_{i,t-1} + \sigma_{\Delta\tau,i,t} \times \eta_{\tau,i,t}; \tag{4}$$

$$\varepsilon_{i,t} = \sigma_{\varepsilon,i,t} \times s_{i,t} \times \eta_{\varepsilon,i,t}; \tag{5}$$

$$\alpha_{i,\tau,t} = \alpha_{i,\tau,t-1} + \lambda_{i,\tau}\zeta_{i,\tau,t}; \tag{6}$$

$$\alpha_{i,\varepsilon,t} = \alpha_{i,\varepsilon,t-1} + \lambda_{i,\varepsilon}\zeta_{i,\varepsilon,t}. \tag{7}$$

The parameter setting of Eqs (2)–(7) is given as follows: assume that $\lambda_{i,\tau}$ and $\lambda_{i,\varepsilon}$ both follow an inverse Gamma distribution, and that the priori value of $\alpha_{i,\tau,t}$ and $\alpha_{i,\varepsilon,t}$, namely $\alpha_{i,\tau,0}$ and $\alpha_{i,\varepsilon,0}$, is a random value following $N\left(0, \kappa_1^2 ll' + \kappa_2^2 I_n\right)$ respectively, in which l is a $n\times1$ dimensional column vector whose elements are all equal to 1. Let the respective innovation variances $\sigma^2_{\Delta\tau,c,t}$, $\sigma^2_{\Delta\tau,i,t}$, $\sigma^2_{\varepsilon,c,t}$, and $\sigma^2_{\varepsilon,i,t}$ of $\tau_{c,t}$, $\tau_{i,t}$, $\varepsilon_{c,t}$, and $\varepsilon_{i,t}$ all follow a logarithmic random walk process, whose corresponding amplitudes are $\gamma_{\Delta\tau,c}$, $\gamma_{\Delta\tau,i}$, $\gamma_{\varepsilon,c}$, and $\gamma_{\varepsilon,i}$:

$$\ln\sigma^2_{\Delta\tau,c,t} = \ln\sigma^2_{\Delta\tau,c,t-1} + \gamma_{\Delta\tau,c}\nu_{\Delta\tau,c,t}; \tag{8}$$

$$\ln\sigma^2_{\Delta\tau,i,t} = \ln\sigma^2_{\Delta\tau,i,t-1} + \gamma_{\Delta\tau,i}\nu_{i,t}; \tag{9}$$

$$\ln\sigma^2_{\varepsilon,c,t} = \ln\sigma^2_{\varepsilon,c,t-1} + \gamma_{\varepsilon,c}\nu_{\varepsilon,c,t}; \tag{10}$$

$$\ln\sigma^2_{\varepsilon,i,t} = \ln\sigma^2_{\varepsilon,i,t-1} + \gamma_{\varepsilon,i}\nu_{i,t}, \tag{11}$$

where $\left(\varepsilon_{c,t}, \varepsilon_{i,t}, \eta_{c,t}, \eta_{i,t}, \zeta_{c,t}, \zeta_{i,t}, \nu_{\Delta\tau,c,t}, \nu_{\varepsilon,c,t}, \nu_{\Delta\tau,i,t}, \nu_{\varepsilon,i,t}\right)$ are independent from each other, and follow a standard normal distribution. Let $s_{c,t}$ and $s_{i,t}$ denotes common temporary volatility factor and sectoral temporary volatility factor, respectively. The two types of price outlier factors are used to tackle with the non-trending outliers. They both follow a multinomial distribution whose priori value is 1, 5, and 10 with the corresponding priori probability of 0.975, 1/60 and 1/120, respectively. Now we can use Eq. (12) to describe sectoral core inflation, in which core inflation in category i consists of weighted common trend factor $\alpha_{i,\tau,t}\tau_{c,t}$ and sectoral trend factor $\tau_{i,t}$:

$$\tau^{core}_{i,t} = \alpha_{i,\tau,t}\tau_{c,t} + \tau_{i,t}. \tag{12}$$

The overall core inflation $\tau^{core}_{i,t}$ is a weighted sum of all sectoral core inflations:

$$\tau^{core}_{t} = \sum_{i=1}^{8} w_i \tau^{core}_{i,t}, \tag{13}$$

where w_i denotes the weighted coefficient of category i in core inflation, and $\alpha_{i,\tau,t}$ denotes the contribution of common trend factor to sectoral inflation in category i. The influence of common trend factor on various categories will change in consequence as $\alpha_{i,\tau,t}$ changes. Following the multi-variable Gaussian mixed estimation as in Omori et al. (2007), we obtain a posterior parameter estimation through 10,000 iterations of the Markov Chain Monte Carlo (MCMC) simulation. Parameters $\gamma_{\Delta\tau,c}$, $\gamma_{\Delta\tau,i}$, $\gamma_{\varepsilon,c}$, and $\gamma_{\varepsilon,i}$ all priori follow an independent uniform distribution $U(0, 0.5)$. The initial value of common trend factor $\tau_{c,t}$ is set to be 0. The initial value of $\alpha_{i,\tau,0}$ and $\alpha_{i,\varepsilon,0}$ is set to be $\kappa_1 = 10$ and $\kappa_2 = 0.4$, respectively. The filtering estimation of unobserved component is accessible through the conditional mean of contemporaneous data. Other parameters are accessible through the posterior mean of the entire set of data.

4. Model estimation

4.1. Data processing

This paper uses the month-on-month growth rates of the CPI and sectoral inflation in eight categories to estimate China's core inflation and sectoral core inflation as indicated above. The data is pre-processed as follows: 1) considering the adjustment of the CPI's statistical caliber, we first divide the sampling period into two segments, namely 2006M1–2015M12 and 2016M1–2020M12. 2) To supplement the missing monthly chained data, we use the year-on-year data for inverse interpolation, and obtain consecutive time series. 3) We process the two segments' month-on-month growth rates of the CPI and of sectoral inflation in eight categories using the X-13ARIMA-SEATS seasonal adjustment program to remove the impact of pure seasonal factors.

Table 1. Stationary test results

2006.01–2015.12				2016.01–2020.12			
Sector	P value	Sector	P value	Sector	P value	Sector	P value
Food	0.000	Health care and personal articles	0.000	Food, tobacco and liquor	0.000	Transportation and communications	0.000
Tobacco, liquor and articles	0.000	Transportation and communication	0.000	Clothing	0.000	Education, culture and recreation	0.000
Clothing	0.048	Recreation, education and culture articles	0.000	Residence	0.065	Health care	0.000
Household facilities, articles and services	0.061	Residence	0.000	Articles for daily use and services	0.054	Other articles and services	0.000

After pre-processing data, we continue to process data according to model requirement. Since the MUCSVO model is estimated using the Kalman filter, data must be stationary and follow a normal distribution. On the one hand, we examine whether data is stationary; if it is not, we need de-trend it using the method of logarithm difference. On the other hand, we examine whether the stationary data follows a normal distribution; if it is not, we need remove extreme outliers (Stock & Watson, 2016).

Table 1 shows that China's month-on-month data of sectoral inflation in eight categories is stationary in both segments, which means that further processing is not needed. However, after examining the distribution of basic data, we find that the kurtosis of sectoral inflation data in most categories exceeds 3, which suggests that basic data is leptokurtic with excess kurtosis and sharp peak rather than mesokurtic with a normal distribution. Thus, we need remove extreme outliers according to Eqs (3) and (5) before further estimation.

4.2. Estimation of the weight of sectoral core inflation

In order to restore the weight of sectoral core inflation in core inflation to the largest extent, we estimate it using overdetermined set of equations that allows an infinite approximation to the true solution according to constraint and empirical simulation. By strictly following the base-period rotation principle every five years, we divide the sampling period into three segments, namely segment I during 2006–2010, segment II during 2011–2015 and segment III during 2016–2020, whose weighting coefficient vector is W_1, W_2 and W_3, respectively. The overdetermined set of equations is defined as follow:

$$(w_1\ w_2 \cdots w_8)\begin{pmatrix} \pi_1^1 & \pi_1^2 & \cdots & \pi_1^8 \\ \pi_2^1 & \pi_2^2 & \cdots & \pi_2^8 \\ \vdots & \vdots & \ddots & \vdots \\ \pi_8^1 & \pi_8^2 & \cdots & \pi_8^8 \end{pmatrix} = (\pi^1\ \pi^2 \cdots \pi^8), \tag{14}$$

where π^j and π_i^j denotes the overall headline inflation and sectoral headline inflation in category i at time j, respectively, and w_i is the weight of category i. Since the data of the overall headline inflation and sectoral headline inflation is available at all times, we can calculate weighting coefficient using the method of undetermined coefficient. We rewrite Eq. (14) in a matrix form $W \times P = \pi$, in which W denotes sectoral weighting coefficient vector, $P = [P_1, P_2, ..., P_8]$ denotes sectoral headline inflation matrix at eight different times. Taking the calculation of W_1 for example, given the sample size of 60 sets of time-point data during 2006M1–2010M12, we traverse 8 out of 60 sets of time-point data as each representative sample group of sectoral inflation, P_j, to construct overdetermined set of equations, which means that we can obtain C_{60}^8 unary system of octonionic equations of W_1, and thereby a total number of 2,558,620,845 weighting solutions $W_1^n = \left\{w_1^n, w_2^n, ..., w_8^n\right\}$, n = 1, 2, 2558620845. Moreover, valid weight must satisfy two constraints: the sum of weights must be between 0.9999 and 1.0001 (i.e., $0.9999 \le \sum_{i=1}^{8} w_i \le 1.0001$); single category weight must be between 0.02 and 0.5 (i.e., $0.02 \le w_i \le 0.5$). The former is given for the validity and accuracy of solution, as a solution exactly equal to 1 may be difficult to realize. The latter is given based on the time-point data published by the NBS and empirical judgement, as single category weight is usually neither too large nor too small. There are 351,741 weighting solutions that satisfy both constraints. We multiply weighting solutions by sectoral headline inflation to obtain the fitted value of headline inflation, then select weighting solutions with the smallest sum of squared residuals between the fitted and actual values as the optimal group of weighting solutions, W_1^*. The corresponding selection is as follows:

$$\min_n \sum_{j=1}^{60} \left(\sum_{i=1}^{8} w_i^n \times \pi_i^j - \pi_j \right)^2. \tag{15}$$

Similarly, we can calculate W_2^* and W_3^* as shown above. The weights of sectoral core inflation in China's eight categories during the three segments in the overall core inflation are given in Table 2[2].

Table 2 clearly reveals structural changes in core inflation weight. First, the weight of food, tobacco and liquor consumption has declined from the initial 43% to 30%. The economic significance of this result is that the proportion of living necessities including food in household

[2] For nations whose base-period rotation cycle (n months) is relatively long ($n \ge 120$) and number of inflation categories (m categories) is relatively large ($m \ge 10$, $m \ll n$), a computer is highly unlikely to compute C_n^m overdetermined sets of equations. According to the Law of Large Numbers, we use an asymptotic solution method by taking the following steps: 1) as far as computing power allows, we take a number as large as possible, k ($k < n$, $k \gg n$) as the randomly picked number of months k in every fixed-weight segment (n months) as a sample P_j; 2) we traverse m out of k sets of time-point data from sample P_j to construct overdetermined set of equations via Eq. (14), and thereby obtain C_k^m weighting coefficient solutions; 3) we apply a constraint of estimation accuracy, $0.9999 \le \sum_{i=1}^{m} w_i \le 1.0001$, to the solutions, as well as other weighting constraints depending on the actual situation in each nation, and thereby obtain v solutions; 4) we calculate the optimal group of weighting solutions by selecting weighting solutions with the smallest sum of squared residuals between the fitted and actual values given in Eq. (15); 5) we repeat steps 1) to 4) for 100,000 times, and thereby obtain 100,000 optimal groups of weighting solutions; 6) we develop kernel density function using each category's optimal group of weighting solutions, and take weighting value with the highest distribution density as the anchor weight of each category. According to the Law of Large Numbers, this value asymptotically converges to the true value of sectoral weight; 7) According to $\min_v \sum_{i=1}^{m} (w_i^v - w_i^*)^2$, we select the approximate solution among v optimal group of weighting solutions.

consumption has significantly fallen, which is in line with the general rule of income change. Secondly, the weight of residence consumption has stably stayed 10%–16% in segments I and II, while risen up to nearly 20% in segment III, which shows that residence consumption has become a considerably large proportion of household consumption. Given that rental price is a consumption category mostly concerned by the middle-income group, it implies that the proportion of China's middle-income group has significantly risen as well, which also coincides with the conclusion from Zheng et al. (2023).

Thirdly, the weight of health care consumption has been volatile as well (e.g., only 3.5% in segment I, 13.5% in segment II, and 7.3% in segment 3), which witnesses China's transition from high-speed growth to high-quality development. China's real GDP per capita in 2006 is only 17,000 yuan. Most residents (especially rural residents) cannot afford health care consumption, which accounts for its extremely low proportion of household consumption (Huang & Gan, 2017). The boom of health care consumption in segment II is primarily for two reasons. On the one hand, as real income per capita increases, Chinese residents pay closer attention to health and are more willing to consume health care. On the other hand, the medical system in China during this period is so far from perfect that residents have to afford a great amount of medical expenses themselves, which also leads to the boom of health care consumption. In segment III, along with continuous improvements in medical insurance policy such as medical treatment in different places, China's medical insurance system reform has made a substantial progress. It has greatly reduced the difficulty of accessing medical service, enlarged the coverage of medical insurance, and lowered the amount of health care consumption afforded by residents themselves.

Table 2. The overdetermined system of equations estimation results of core inflation weight

Period I (2006.01–2010.12)		Period II (2011.01–2015.12)		Period III (2016.01–2020.12)	
Sector	W_1^*	Sector	W_2^*	Sector	W_3^*
Food	33.66%	Food	32.09%	Food, tobacco and liquor	30.07%
Tobacco, liquor and articles	9.41%	Tobacco, liquor and articles	2.20%	Clothing	8.11%
Clothing	7.31%	Clothing	10.47%	Residence	19.03%
Household facilities, articles and services	5.43%	Household facilities, articles and services	6.17%	Articles for daily use and services	7.87%
Health care and personal articles	3.49%	Health care and personal articles	13.54%	Transportation and communications	11.82%
Transportation and communication	12.43%	Transportation and communication	10.05%	Education, culture and recreation	11.66%
Recreation, education and culture articles	12.33%	Recreation, education and culture articles	14.86%	Health care	8.32%
Residence	15.93%	Residence	10.62%	Other articles and services	3.12%

Lastly, based on the changes of household consumption weights and empirical statistics in Figure 2, we can draw four economic and policy implications. First, food consumption has been less important over the past fifteen years, while residence consumption becomes more important meanwhile. Besides an expansion of the middle-income group, it is key to monitor rental price volatility in time and to prevent excessively rapid rises in rental price for taking precaution on a structural imbalance of consumption and defending the well-being of the middle-income groups. Secondly, food consumption still accounts for the largest proportion of household consumption despite the declining trend. The proportion sum of food and residence consumption is still up to 50%, which suggests that food consumption mostly concerned by the low-income group and residence consumption mostly concerned by the middle-income group are still main contributors to household consumption in China. It also shows that a substantial gap of real income per capita remains between China and developed economies. Thirdly, the empirical evidences in segment III show that the food category's extremely high weight in segment I (33.66%) and the tobacco, liquor and articles category's extremely low weight in segment II (2.20%) no longer exist in the current price system. On the contrary, sectoral consumption structure becomes more reasonable and balanced, which implies that China's consumption structure has fundamentally changed. As the consumption of different groups diverges into different categories, the trending volatility of sectoral inflation, which is an inflation indicator directly relevant to the immediate interests of the public, deserves closer attention than fluctuations in the overall inflation. Fourthly, according to overdetermined set of equations' estimated weight and the NBS's data of consumption share published after 2013, they are consistent in general but have some minor differences. As shown in Figure 2, the proportion of residence consumption constantly stays 23–26% according to the official data, but the NBS only assigns it a weight of 19.03% based on empirical measurement. Similarly, the proportion of transportation and communications consumption remains 13–14% according to the official data, but the NBS only assigns it an underestimated weight of 11.82% based on empirical measurement. It shows that the NBS may have made some subjective weighting adjustment in order to weaken the structural contradictions of price in some categories. Nevertheless, it does not exert a sizeable influence on the overall inflation indicator. The official data maintains relatively strong objectivity and credibility.

4.3. Robustness test

The model estimation results are tested for robustness in terms of trend and volatility. The trend test is based on the mean test as in Clark (2001) and the persistence test as in Boivin et al. (2009). The principle of a mean test is that core inflation and headline inflation should have consistent long-term trend. That is, there should be no systematic difference between the mean of series $\pi_{i,t}$ and $\pi_{i,t}^{core}$, which can be tested through conducting a mean test on their difference. The principle of a persistence test is that core inflation should not have any temporary components. Thus, the persistence of core inflation should be stronger than that of headline inflation, which can be tested through the sum of autoregressive coefficient (SARC).

$$z_t = \alpha_0 + \sum_1^q \alpha_i z_{t-i} + \varepsilon_t, \tag{16}$$

where z_t denotes the tested variable, the optimal lag order q is determined by Akaike infor-

mation criterion (AIC) and Schwarz criterion (SC), and the persistence parameter of indicator is $\rho = \sum_{i=1}^{q} \alpha_i$. Thus, we can examine whether an indicator is reasonably constructed according to the value of ρ. Following Marques et al. (2003), we conduct a volatility test and unit root test on core inflation. The principle of volatility test is that core inflation should exclude temporary volatility component, thus its volatility should be lower than that of headline inflation. The principle of unit root test is that temporary volatility component excluded from core inflation should be stationary without any trends. The results of robustness test are given in Table 3.

Table 3 shows that the volatility of all core inflation indicators is significantly lower than that of headline inflation, which indicates that the MUCSVO model augmented with overdetermined set of equations can effectively remove the temporary volatility component of headline inflation. All volatility components pass unit root test, which suggests that it is reasonable to exclude volatility. According to the mean test results, we cannot reject the null hypothesis that $\pi_{i,t}$ and $\pi_{i,t}^{core}$ have the same mean in all categories, which means that core inflation constructed by our model can effectively trace the long-term trend of headline inflation. Lastly, the persistence test results show that the persistence of core inflation in all categories is higher than that of headline inflation, which implies that core inflation estimation is valid.

Table 3. Robustness tests on the MUCSVO core inflation system

Period	Variable	Volatility		Unit root test	Mean test	Persistence test	
		Headline	Core		(P value)	Headline	Core
Period I, II (2006.01–2015.12)	CPI	0.37	0.19	–12.54***	0.55	0.33	0.74
	Food	0.94	0.31	–12.47***	0.55	0.36	0.88
	Tobacco, liquor and articles	0.27	0.11	–7.76***	0.14	0.32	0.96
	Clothing	0.25	0.17	–9.02***	0.74	0.71	0.95
	Household facilities, articles and services	0.14	0.10	–16.08***	0.32	0.73	0.91
	Health care and personal articles	0.15	0.09	–11.73***	0.90	0.36	0.88
	Transportation and communication	0.27	0.09	–7.28***	0.65	0.03	0.81
	Recreation, education and culture articles	0.32	0.08	–17.32***	0.72	–0.31	0.99
	Residence	0.43	0.41	–14.15***	0.28	0.62	0.78
Period III (2016.01–2020.12)	CPI	0.34	0.13	–8.54***	0.97	0.54	1.28
	Food, tobacco and liquor	1.54	0.35	–7.52***	0.97	0.67	0.77
	Clothing	0.41	0.05	–9.40***	0.72	0.00	0.86
	Residence	0.15	0.11	–9.31***	0.98	0.69	1.14
	Articles for daily use and services	0.12	0.07	–11.44***	0.99	0.55	1.11
	Transportation and communications	0.71	0.33	–8.69***	0.71	0.05	0.69
	Education, culture and recreation	0.71	0.08	–11.35***	0.72	–0.92	0.89
	Health care	0.27	0.14	–7.27***	0.48	0.33	0.54
	Other articles and services	0.69	0.11	–8.04***	0.78	0.43	0.91

5. Empirical result analysis

5.1. Characteristics of China's core inflation system

Figure 3 depicts the in-sample trends of core inflation and headline inflation with four economic implications. First, the trend of core inflation is relatively steady, while that of headline inflation is relatively volatile, which suggests that headline inflation is full of short-term price volatility. Secondly, headline inflation is significantly higher or lower than core inflation during different sampling periods (e.g., higher in 2008M2 and 2020M2 and lower in 2012M2 and 2017M2), which suggests that it is inaccurate to measure price trend using headline inflation only, and may lead to serious misjudgment. This coincides with Fasanya and Awodimila (2020), Giri (2022). Thirdly, core inflation has experienced a short-term trending contraction during 2008M6–2008M12 and trending recovery during 2009M1–2010M11 only. Its trend has been quite steady with a moderate month-on-month growth rate near 0.2% since 2012, which implies that China's inflation operates well in general, and hardly exists a long-term trending inflation or deflation. Fourthly, headline inflation is abnormally volatile occasionally. For example, headline inflation has fallen sharply due to cyclical price plunges in pork and other food products during 2017M2–2017M5. A headline deflation occurs in March 2018, which is majorly caused by collective price plunges in communication device by 2.7% and refined oil products by 2.6%. It is evident that China's overall steady inflation is full of typical abnormal sectoral price volatility, which neutralizes each other across categories. Thus, we ought to pay close attention to characteristic changes in sectoral core inflation, which is critical to solving the puzzle of China's low inflation.

Figures 4a–c depict the in-sample trends of sectoral core inflation in different segments. As shown in Figure 4a, the trends of sectoral core inflation are clearly divergent in segment I, in which the categories of food, residence and household, facilities, articles & services have the highest price volatility. Given that the weight sum of these categories is up to 55%, they are trending price volatility leaders. As shown in Figure 4b, the trends of sectoral core inflation are relatively steady in segment II, in which the late trends of the categories of tobacco, liquor and articles and household, facilities, articles and services almost overlap zero. Based on the estimation results of overdetermined set of equations, their proportions are obviously low and trends of sectoral core inflation are hardly observed in segment II. It shows that their

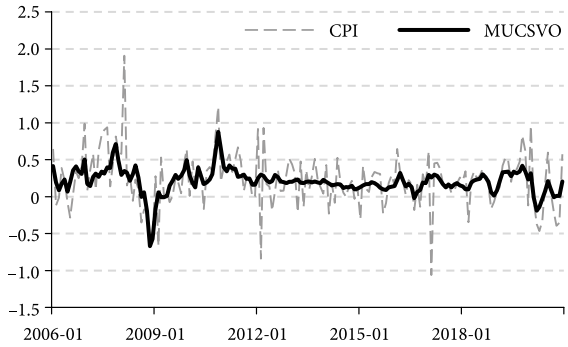

Figure 3. Trend of core and headline inflation

monitoring value has significantly declined, which is also an important reason to combine them in the new eight inflation categories. As shown in Figure 4c, the trends of sectoral core inflation show individual characteristics as well as being divergent again, which is majorly in the form of price hedge. Taking the most obvious price hedge between the food, alcohol and liquor category and the transport and communication category during 2018–2020 for example, the month-on-month growth rate of sectoral CPI in the food, alcohol & liquor

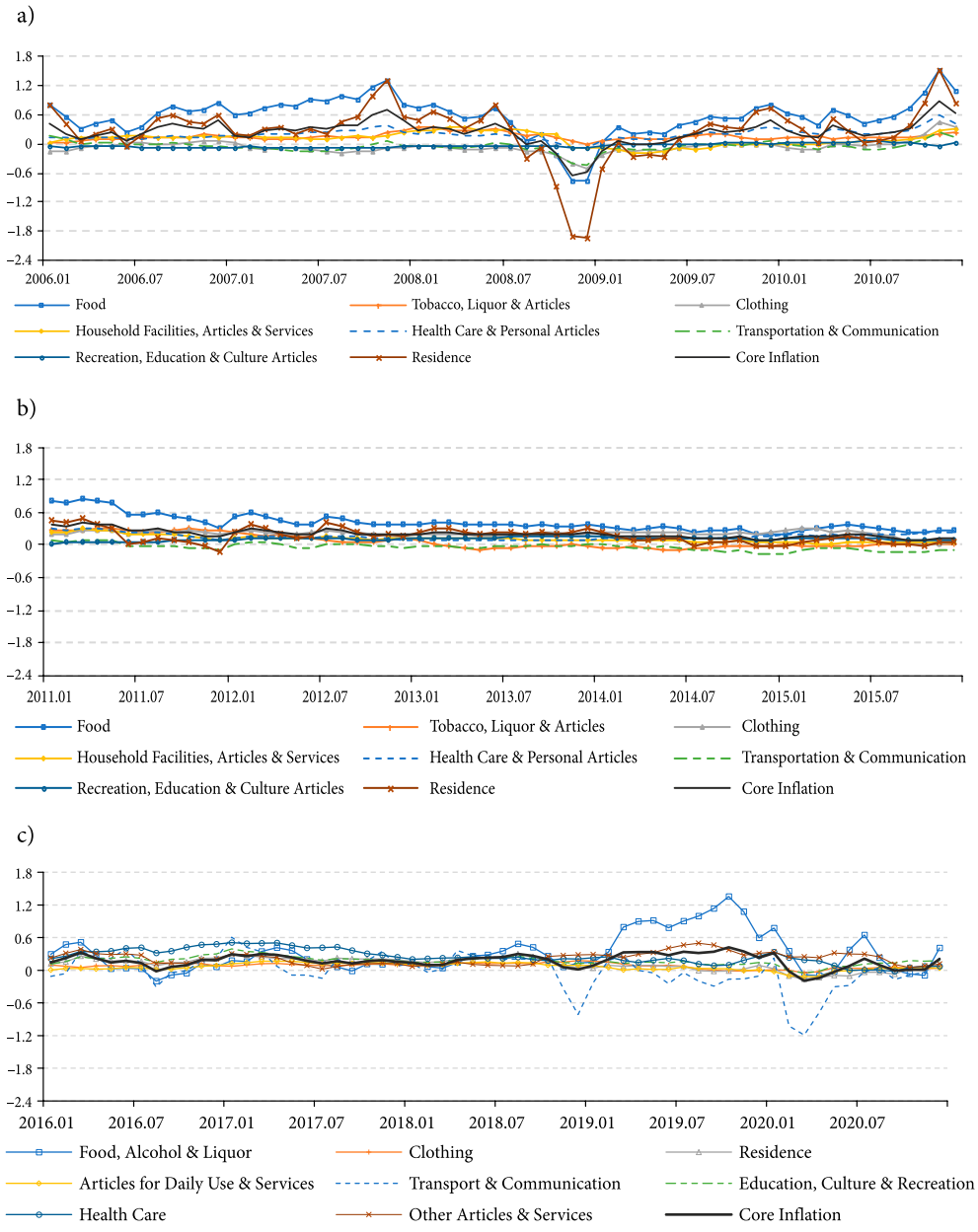

Figure 4. Sectoral core inflation in: a – segment I; b – segment II; c – segment III

category is as high as 4% at the end of 2019. However, thanks to the monthly deflation rate of sectoral CPI in the transport and communication category near 1%, the overall CPI stays around 2% without significant abnormality. Thus, instead of what it looks like as a desirable phenomenon, China's low inflation is full of typical sectoral price structural imbalance. Given the strong inflation in food sector during 2019–2020, as well as the connection between food consumption and the low- and middle-income groups, the low- and middle-income groups mainly bear this round of local inflation. Moreover, considering the population of the low- and middle-income groups (Shi et al., 2022), it is not difficult to understand why the public believes that there is a severe inflation in China at present despite the moderate overall CPI published by the NBS. This finding is an important supplement for Fan et al. (2022), that is, an overall low inflation doesn't mean that no one is suffering from inflation.

5.2. Sectoral core inflation decomposition and contribution measurement

This subsection further identifies the causes of core inflation volatility in three steps: 1) decompose sectoral core inflation into sectoral co-movement component and individual component according to Eqs (12) and (13), which identifies the causes of sectoral core inflation volatility; 2) measure the contributions of the two components to the overall core inflation, which identifies the causes of the overall core inflation volatility; 3) decompose the historical contribution of the overall core inflation at each time point, and measure the proportions of the two components in core inflation over time, which provides empirical evidence to predict future core inflation trend.

Figures 5a–c depict the in-sample trends of sectoral co-movement component in different segments (i.e., $\alpha_{i,\tau,t}\tau_{c,t}$ in Eq. (12)). As shown in Figure 5a, sectoral co-movement component, whose influences on the food category and residence category are extremely strong, barely affects other categories in segment I. The strongest influences take place during 2007M7–2007M12 and 2008M9–2009M3, which strongly coincides with trending changes in the overall core inflation in Figure 3. It shows that the co-movement of sectoral price will shape the overall core inflation, which is consistent with the conclusions of Hu and Zhang (2021). As a result, China's monetary authority promptly responds to these rounds of inflation and deflation by carrying out counter-cyclical monetary policy. In segments II and III, the influences of sectoral co-movement component on sectoral core inflation in all categories are extremely weak. The economic significance of this result is that China's sectoral price volatility is mainly brought by sectoral individual component instead of rare sectoral co-movement component at present. Considering the obvious trade-off among sectoral individual components, China's inflation has been implicit since segment II. That is, the overall inflation indicator hides the prominent contradiction among sectoral inflation trends.

Figures 6a–c depict the in-sample trends of sectoral individual component in different segments. Inflation principally emerges in the food category and residence category in segments I and II, when sectoral inflation shows an upward trend and grows at a month-on-month rate of 0.6% in the food category. This means that China has experienced an annualized food inflation as high as 7% for five years. The sectoral inflation in the residence category shows an upward trend too during 2007–2009. Considering that the low- and middle-income groups are mostly concerned with food and residence, they mainly undertake the costs of high inflation, which is also a trigger of China's imbalanced and inadequate development.

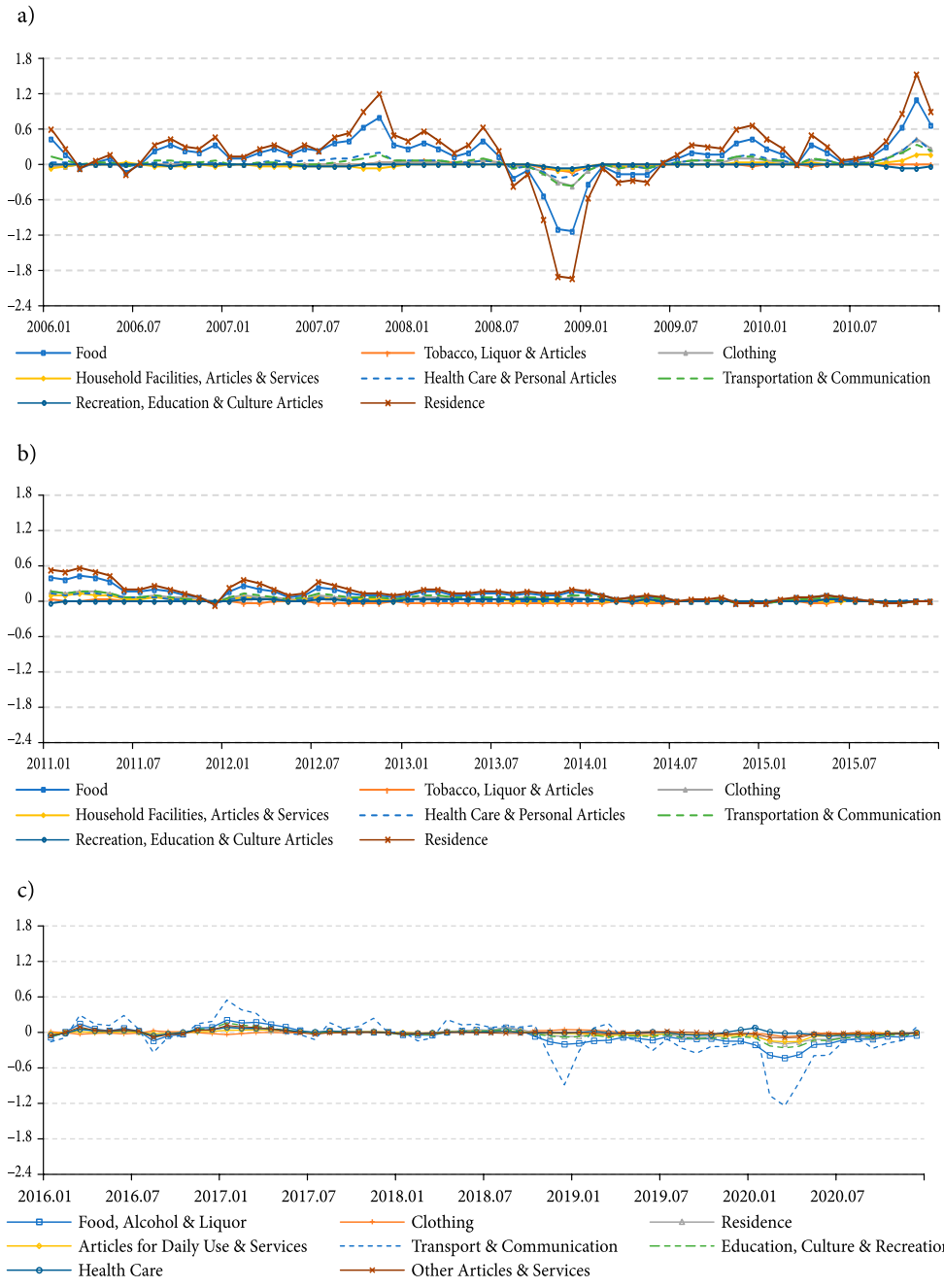

Figure 5. Sectoral co-movement component in: a – segment I; b – segment II; c – segment III

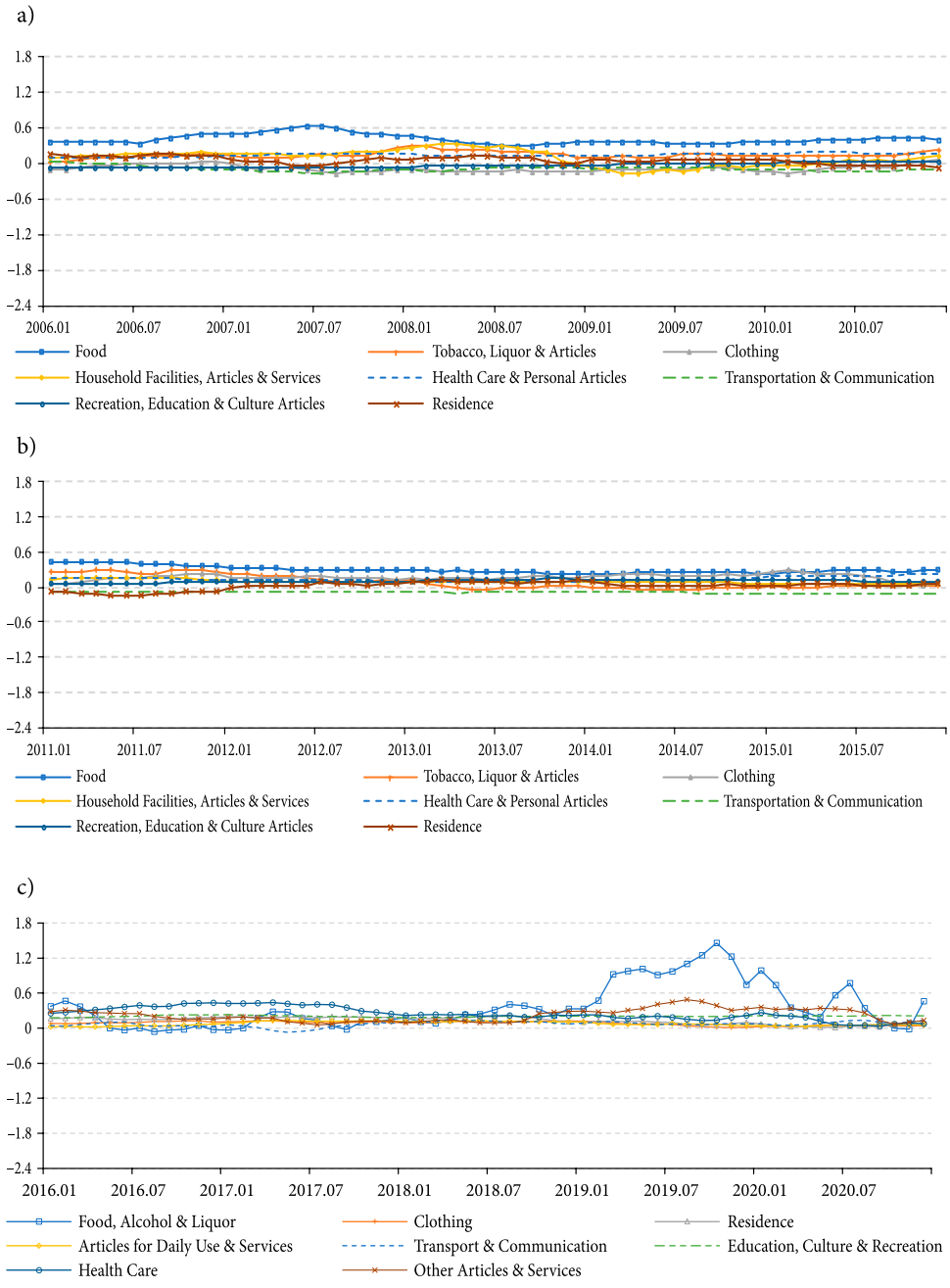

Figure 6. Sectoral individual component in: a – segment I; b – segment II; c – segment III

In segment III, the upward trends of sectoral inflation in the food category and residence category have eased, while price level in the health care category becomes significantly volatile, which grows at a month-on-month rate of 0.4%–0.5% for more than two years. Considering that the low- and middle-income groups are also concerned with heath care, their well-being is still in a dilemma shifting from food and shelter to basic livelihood. Meanwhile, due to decelerated economic growth and inadequate internal demand, sectoral individual component shows a deflation in other categories, which hedges sectoral inflation in the health care category, and thereby leads to steady overall CPI. The economic significance of this result is that the overall inflation indicator is no longer able to reflect the structural imbalance of China's price system at present. Sectoral inflation divergence has become the most prominent contradiction of China's inflation system. This is in contrast to the inflation pattern of many economies (e.g., the US and Europe). Bermingham (2010), Aras and Lisboa (2022) and Kim and Lim (2022) propose that as the US, South Korea and most other developed economies have entered the high-income stage, the proportion of food consumption in total consumption is relatively small, thus core inflation trend is less influenced by the food category. As a result, most studies choose to target core inflation trend for inflation regulation and expectation management. However, targeting the overall core inflation is insufficient for China, since the low- and middle-income groups make up a large proportion. Therefore, besides monitoring and regulating price level using aggregate monetary policy, we need pay closer attention to sectoral CPI, especially those highly concerned by the low- and middle-income groups. We also need take the administrative means of sectoral inflation control such as price regulation and consumption stamp into account.

To further support our conclusion, we develop two contribution indicators as shown in Eqs (26) and (27) in a way of revealing the composition of the overall core inflation in the three segments more accurately:

$$\Phi_{i,t,t} = \frac{w_i \left|\alpha_{i,t,t}\tau_{c,t}\right|}{\sum_{i=1}^{8} w_i \left\{\left|\alpha_{i,t,t}\tau_{c,t}\right| + \left|\tau_{i,t}\right|\right\}}; \tag{26}$$

$$\Phi'_{i,t} = \frac{w_i \left|\tau_{i,t}\right|}{\sum_{i=1}^{8} w_i \left\{\left|\alpha_{i,t,t}\tau_{c,t}\right| + \left|\tau_{i,t}\right|\right\}}, \tag{27}$$

where Eqs (26) and (27) respectively measures the contribution of sectoral co-movement component and of sectoral individual component to core inflation as shown in Table 4.

In segment I, the cumulative contribution of the food category and the tobacco, liquor and articles category is 42.6%, and the cumulative contribution of sectoral co-movement component is 39.1%. It shows that there is a significant co-movement of sectoral inflation in China, in which the food category leads trending changes in sectoral price. In segment II, the proportions of the food category and sectoral co-movement component decline, which suggests that China's core inflation system begins to transform to a diversified and divergent pattern. In segment III, the structure of China's core inflation system continues to reform. On the one hand, the proportion of sectoral co-movement component continues to decline to 26.8%, which implies that sectoral individual component leads trending changes in sectoral price.

Table 4. Contributions of sectoral co-movement component and individual component to core inflation

Category	2006.01–2010.12		2011.01–2015.12			2016.01–2020.12	
	Co-movement	Individual	Co-movement	Individual	Sector	Co-movement	Individual
Food	0.117	0.223	0.071	0.204	Food, tobacco and liquor	0.100	0.310
Tobacco, liquor and articles	0.007	0.079	0.011	0.054	Clothing	0.004	0.030
Clothing	0.020	0.044	0.029	0.122	Residence	0.030	0.113
Household facilities, articles and services	0.011	0.074	0.015	0.060	Articles for daily use and services	0.007	0.026
Health care and personal articles	0.030	0.082	0.014	0.097	Transportation and communications	0.091	0.039
Transportation and communication	0.029	0.045	0.039	0.071	Education, culture and recreation	0.024	0.098
Recreation, education and culture articles	0.004	0.021	0.011	0.074	Health care	0.008	0.091
Residence	0.173	0.041	0.091	0.037	Other articles and services	0.003	0.025
Cumulative contribution	0.391	0.609	0.281	0.719	Cumulative contribution	0.268	0.732

On the other hand, the contribution of the food, tobacco and liquor category rises to 41% again, and dominates among all categories. There are three economic and policy implications of these results. First, the declined proportion of sectoral co-movement component suggests that the overall inflation is principally led by sectoral individual component that usually hedges against each other across categories. Furthermore, it suggests that the economic significance of monitoring the overall inflation indicator has greatly declined. Secondly, price level in the Food, tobacco and liquor category leads inflation again in segment III, which shows that the COVID-19 pandemic has indeed brought negative impact on Chinese economy. In particular, the uncertainty arisen from the COVID-19 pandemic and the corresponding control and prevention measures has directly led to surges in precautionary demand for food as well as food price volatility. Thirdly, considering the importance of the food category to the low-income groups, the government should monitor sectoral price volatility in the food category, and carry out timely policies including price regulation, consumption stamp, etc. to stabilize it.

Lastly, in order to capture changes in the contributions (measured by proportions) of sectoral co-movement component and individual component to core inflation, we depict historical contribution decomposition based on their cumulative contribution at each time point in Figure 7. First, the proportion of sectoral co-movement component in core inflation

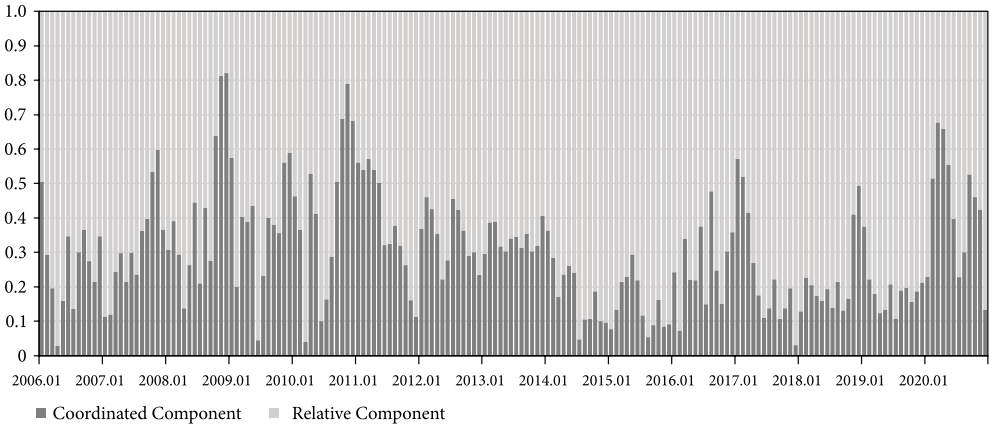

Figure 7. Changes in the contributions of sectoral co-movement component and individual component to core inflation

has clearly declined over time, which is highly consistent with the conclusions of previous studies. Secondly, the proportion of sectoral co-movement component reaches the historical peak up to 80% at the core deflation stage in January 2009. It shows that deflation (relative to inflation) is more likely to cause sectoral co-movement and structural imbalance, thus is more of a priority for identification and prevention. Thirdly, the proportion of sectoral co-movement component has significantly increased since the breakout of the COVID-19 pandemic in 2020, which arises from surges in precautionary consumption and supply shortage. Considering that they both cause higher price level, China's low inflation may come to an end. A persistently rising and highly volatile core inflation is very likely to become the new tone of China's core inflation system.

6. Conclusions

In order to trace the long-term price trend across categories, this paper develops a structural dynamic factor model by integrating the algorithm of overdetermined set of equations with the MUCSVO to capture the overall and individual trends of inflation as well as forecast sectoral price weights. Our model is also a feasible means for characterizing price structure, analyzing the internal mechanism of price volatility and predict the direction of sectoral inflation. The main conclusions can be summarized as follows.

First, in terms of changes in household consumption structure, China has experienced a pivotal period of structural transformation of household consumption over the past fifteen years. Besides evolving to a more equalized direction, sectoral individual price trend begins to lead inflation volatility. Nevertheless, considering the weighting sum of the food category and residence category still exceeds 50%, the low- and middle-income groups are still main contributors to household consumption in China. It also shows that China's real consumption structure, which still has typical characteristics of developing and middle-income economies, is far from that of developed and high-income economies.

Secondly, in terms of trending changes in sectoral inflation, the main contradiction of China's inflation has been shifting from high price level in the traditional categories of food and residence to atypical inflation in the health care category. Nevertheless, considering that the low- and middle-income groups are also highly concerned with health care, their actual difficulties of basic livelihood and China's imbalanced as well as inadequate development have not been substantially resolved, but only sectoral contradiction shifts.

Thirdly, in terms of the puzzle of China's low inflation, rather than being isolated from inflation concerns, it arises from the obvious trade-off among sectoral inflation that polishes the overall inflation data to a great extent. As a result, the overall low inflation hides behind the severe imbalance of sectoral price level. Thus, it is concluded that the problem of local inflation is still significant, although China's overall inflation and deflation will be much less likely to occur. The economic significance of monitoring the overall CPI has considerably declined. Instead, it is necessary to monitor inflation with respect to sectoral volatility in future, especially those in the food, residence and health care categories which are highly concerned by the low-income groups.

Fourthly, in terms of the marginal contribution of this paper, our augmented MUCSVO model is applicable to measure core inflation in economies that do not publish inflation weights as well as capturing the structural inflation in China. As global inflation enters an era of structural differentiation across categories, it is a useful extension of core inflation measurement and prediction, and is of great reapplication value.

The practical, theoretical and societal implications of this paper are given below. Practically speaking, the government should build a monitoring system of sectoral core inflation to conduct real-time analysis of trending sectoral price changes. Price regulation calls for targeted structural adjustment (e.g., price control, consumption stamp, etc.) as well as general monetary policy, so that price system will maintain moderate and steady, and not be of structurally imbalance. Theoretically speaking, the puzzle of China's low inflation reveals that trade-off among sectoral CPI may stabilize the overall CPI, which leads to unrealistic price stability. In fact, this harmful phenomenon can mislead the monetary authority, and result in sizeable inflation cost. The corresponding social welfare loss will be tremendous, especially when high inflation principally exists in the food, residence and health care categories largely concerned by the low-income group. Thus, future studies on inflation must be extended to sectoral angle. By considering inflation as a system operating in a structural way, we should focus on both aggregate volatility and structural adjustment. Societally speaking, the current mechanism for constructing inflation indicator is problematic. This is not only the case in China but also in other economies (Behera & Patra, 2022; Arango-Castillo et al., 2023). The well-known Laspeyres index is calculated using consumption as a weight. Given that the consumption of the low-income group is usually lower than the high-income group's, the high-income group will be assigned a higher weight. However, inflation usually occurs in the food, residence and health care categories that largely concerned by the low-income group, which leads to a public perception of high inflation coinciding with rarely volatile overall CPI. Thus, potential directions of future inflation studies include constructing inflation indicator in the angle of equal-weight consumer, which facilitates the feedback of real public inflation perception.

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