Analysis of Fluctuation Cycle and Its Influencing Factors of Vegetable Prices in Hebei Province—Based on HP filtering and VAR Model

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***Abstract*—In order to reveal the vegetable price fluctuation in Hebei Province, the research selected Hebei Province vegetable consumption monthly price index from January 2009 to December 2016 as the research object, using the HP filter decomposition model to carry out the cycle division of Hebei Province vegetable price; in order to analyze the factors that affect vegetable price fluctuation in Hebei Province, this research used factor analysis and VAR model to do empirical analysis. The results showed that the fluctuation of vegetable prices in Hebei province has obvious seasonal and cyclical characteristics, the price fluctuation is short, strong amplitude, and the expansion period is longer than the contraction period, and the cycle type is classical; factors such as production cost, purchasing power, population quantity have obvious difference on the size and orientation of influence on vegetable price fluctuation in different time periods.**

***Index Terms*—vegetable prices; fluctuation cycle; influence factor; HP filtering decomposition; VAR model**

I. Introduction

Since the 21st century, the price fluctuation of vegetables has been expanding. The price imbalances such as "garlic you are ruthless" and "ginger your army" are not uncommon. In January 2016, due to the extremely cold weather in China, the price monitoring by Hebei Provincial Price Bureau 4 kinds of vegetable prices dropped 12 liters, eight kinds of road vegetables, the average price of 5.64 yuan / kg, up 7.4% from the previous month, higher than the same period last year 23.7%(Charles,1998). Until the weather warmed in March, the price of vegetables went up but down 40% from a year earlier[1]. The sharp rise in vegetables and the strong fluctuations in vegetables severely affected the stability of the market. They kept the characteristics of price fluctuations and adopted targeted control policies to stabilize prices The market has extremely important practical significance[2].

II. Cycle analysis of vegetable price fluctuation in HeBei Province

The monthly vegetables price index data were selected in this paper, vegetable price index of the same period last year were taken as the base period, this can effectively eliminate the impact of inflation, which can accurately reflect the variation characteristics and laws of the vegetables price.

A. Model introduction

Based on the cycle analysis of the annual fluctuation of vegetable consumption price index in Hebei Province, a more mature HP filter analysis was adopted. HP filtering is a decomposition method of time series in state space, and it is more flexible. It regards the economic cycle as a departure from macroeconomic fluctuations in some slow moving paths, this path grows monotonically over time, and is therefore called a trend[3]. The HP filter increases the frequency of the economic cycle to weaken the cycle fluctuation. The principle of the method is summarized as follows: let {Yt} be an economic time series containing trend components and volatility components, {YtT} is one of the trend components contained in it, reflecting the long-term trend of the original sequence; {Ytc} is the contained fluctuation components, reflecting the deviation from the original sequence of the long-term development trend, {YtT}=, YtT + Ytc, t= 1,2,... T, calculating the HP filtering is to separate the trend component {YtT} from the {Yt}. At the same time, the deviation rate RV= Ytc/ YtT of fluctuation component to trend component can be calculated, it reflects the range in which the sequence deviates from its long-term trend in a certain period of time, thus reflects the short-term fluctuation of the sequence[4].

B. Empirical analysis of vegetable price fluctuation in Hebei Province

1.Data sources and processing

(1) data sources

To ensure the availability of data, this section selects a total of 96 months data of the vegetable consumption

price index (VCR) in Hebei from January 2009 to December 2016, based on the official website of the China Statistics bureau.

(2) data processing

From the data trend graph of vegetable consumption price index (VCR) in Figure 1, it can be clearly seen that the monthly price is obviously seasonal, as a whole, vegetable prices have declined slightly over the past 7 years. In the whole year, the prices of vegetables are characterized by "U", which is relatively high at the beginning and the end of the year.

In order to eliminate seasonality and to grasp the change characteristics of price fluctuation more accurately, seasonal adjustment of CensusX-12 was carried out by using E-views8.0, after eliminating the seasonal and irregular factors, a trend cycle sequence (as shown in Figure 1) was obtained, showing that although the final trend cycle had still relatively high fluctuation, compared with the original sequence, the season adjusted sequence was more smooth, which showed that the vegetable consumption price in Hebei is greatly affected by seasonal factors. From the seasonal factor sequence diagram of (Figure 2), it can be seen more clearly that the fluctuation range of price index was basically the same, and there was obvious seasonality. From the price index irregular factor sequence diagram of (Figure 3), it can be seen that the fluctuation in November to December of 2009, 2012 and 2013 was choppy, volatility in 2015 was relatively large, while the other years were relatively stable, indicating that consumer prices of vegetables in Hebei province was affected by some other irregular factors greatly during the 4 years.

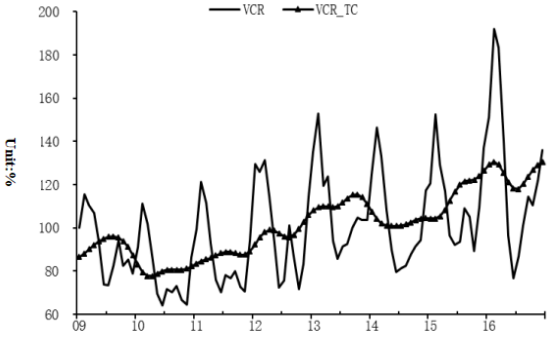

Figure 1: Price index trend cycle chart before and after seasonal adjustment.

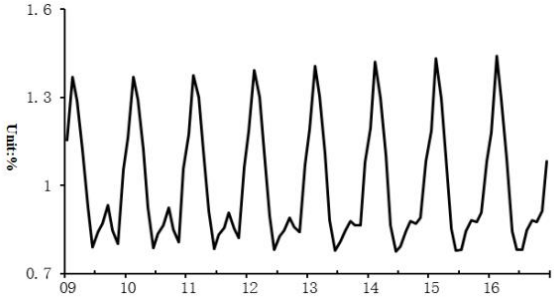

Figure 2: Price index seasonal factor sequence diagram

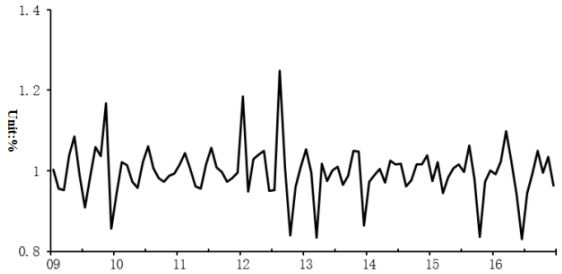

Figure 3: price index irregular factors sequence diagram

2. Cycle division of price fluctuation

(1) long-term trend fluctuation

E-views8.0 was used to decompose the vegetable consumption price index by H-P filter, and the trend components and fluctuation components separated were as shown in (figure 4). Among them, Y is the seasonal adjusted price index sequence, Trend is the trend component separated by filtering, and Cycle is the fluctuation component separated by the filter. It can be seen that the filter decomposition method is better for the long-term trend of vegetable price index, and the fluctuation components through ADF test (as shown in Table I), the t statistics were less than the critical value of each significant level, so the fluctuation component sequence is a stationary sequence.From the long-term trend curve, it can be seen that Hebei province vegetable consumption price index overall performance is very stable, basically a horizontal line. From the fluctuation component curve, we can see that the vegetable consumption price index in Hebei has obviously changed periodically.

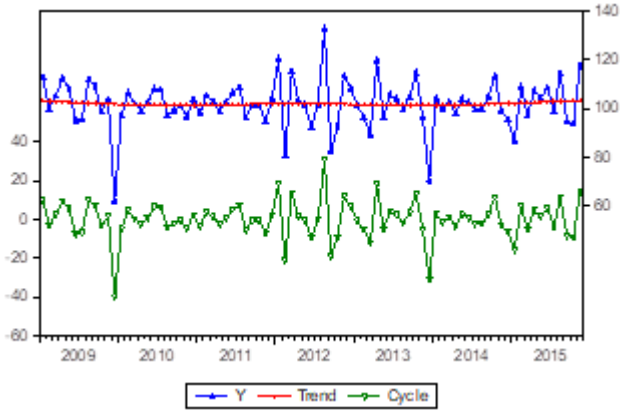

Figure 4: H-P filtering decomposition diagram of vegetable consumption price index.

TABLE I.
FLUCTUATION COMPONENT OF THE STATIONARY TEST

		t-Statistic	Pvalue
ADF statistic		-8.87	0.0000
critical value	1% critical level	-3.51	
	5% critical level	-2.90	
	10%critical level	-2.59	

(2) divide the fluctuation cycle

With the method of "peak-peak", the vegetable consumption price index is divided into 5 cycles, and the result is shown in(table II).

TABLE II.
vegetable consumption price index fluctuation cycle in Hebei Province

cycle	Period	Annual distance (month)	Peak value (%)	Valley value (%)	Fluctuation range (%)	Extension period (month)	Contraction period (month)
1	2009/08-2012/04	32	10.02	-9.54	19.56	7	25
2	2012/05-2013/9	17	9.63	-2.30	11.93	14	3
3	2013/10-2016/02	29	9.49	-7.62	17.11	13	16
Average		26	9.71	-6.49	16.20	11.3	14.67

From table 2 analysis,

a. The average period of fluctuation cycle is 26 months, which belongs to long-term fluctuation

According to the "peak-peak" standard for the cycle division, the Hebei vegetable consumption price index is divided into 3 cycles, the average cycle length is 26(Li,2012). The first cycle is the longest, from August 2009 to April 2012, for 32 months, followed by the third cycle, from October 2013 to February 2016, for 29 months; the second cycle is the shortest, is 17 months. On the whole, the monthly consumption price index of vegetables in Hebei province is seasonal and belongs to long-term fluctuation.

b. The amplitude of fluctuation is relatively high, and belongs to strong amplitude fluctuation type

In the 3 divided periods, the peak value is 9.71%, the peak valley average is -6.49%, the average fluctuation range is 16.20%, and the fluctuation range of each cycle is higher than 10%. The peak value of the first cycle is 10.02%, the peak valley is -9.54%, the fluctuation range is as high as 19.56%, and the fluctuation amplitude of the third cycle is 17.11%. Thus, vegetables in Hebei province monthly consumer price index fluctuations are strong amplitude fluctuations, which shows that Hebei Province vegetables monthly consumer price is easily affected by different factors, which lead to large fluctuations in the price of vegetables.

c. The expansion period is shorter than the contraction period, and the price drop is persistent

In the 3 divided periods, the fluctuation expansion periods of vegetable consumption monthly index in Hebei province respectively are 7 months, 14 months and 13 months, and the average extension period is 11.3 months; the contraction periods respectively are 25 months and 3 months, 16 months, the average contraction period is 14.67 months, the length ratio of the expansion and contraction of 1:1.30, indicating the decline in overall vegetable monthly consumer price index has a certain degree of persistence.

III. EMPIRICAL ANALYSIS OF INFLUENCING FACTORS OF VEGETABLE PRICE FLUCTUATION IN HEBEI PROVINCE

A. Index selection and data processing

In order to reflect the change of vegetable price fluctuation more comprehensively and accurately, not only the supply and demand factors were taken into account, but also some other factors were included in the model, ultimately determine the vegetables consumer price index as the dependent variable, independent variables include the agricultural production goods price index, semi mechanized farm production goods price index, mechanized farm production goods price index, chemical fertilizer production goods price index, per capita disposable income, household consumption level, the disaster rate, the vegetable yield, the permanent resident population these 9 indexes. The index data are derived from the rural statistical yearbook of Hebei Rural Statistical Yearbook and Hebei Economic Yearbook (1996-2016).

B. Factor analysis process

In this paper, SPSS20.0 is used to analyze the data. Under the premise of less loss of sou data information, factor analysis can use less comprehensive index to replace more primitive indicators, and achieve the re classification and dimension reduction of the original variables. These composite indicators represent the primary information of the original indicators, and are not related to each other. They are called common factors.

1. Feasibility test

The KMO test and Bartlett's test were used to carry out factor analysis and feasibility test. KMO is used to measure the partial correlation between variables, with values between 0-1. If the closer to 1 the value is, the more common factors among variables, the more suitable factor analysis is. In this paper, the KMO measure is 0.780, which is suitable for factor analysis. The Bartlett's test is used to check whether the correlation matrix is the unit matrix, that is, to test whether the variables are independent of each other. Under the 1% significance level, if the P value is less than 0.01, the original hypothesis that the correlation matrix is the unit matrix is rejected, that is, there is a correlation between the variables. In this paper, the P value of the Bartlett's test is 0, so rejecting the original hypothesis, showing that factor analysis can be performed (Table III).

TABLE III.
KMO and Bartlett's tests

KMO metric	0.780	
Bartlett's sphericity test	Approximate chi square	300.06
	df	36
	Sig.	<0.000

2. extract common factors

Extract common factors by using principal component analysis, the eigenvalue greater than 1 for the extraction principle, (TableIV) showed that extracting 2 common factors and cumulative variance was 90.465%, showed that the 2 factors representing 90.465% of information,

the information represented by the original data can be more fully explained.

3. Calculate factor load matrix

TABLE IV.
CORRELATION COEFFICIENT MATRIX EIGENVALUE AND VARIANCE CONTRIBUTION RATE

Initial eigenvalue			Rotate quadratic sum loading		
Total	Variance %	Accumulate %	Total	Variance %	Accumulate %
4.59	50.98	50.98	4.50	50.01	50.01
3.55	39.488	90.47	3.64	40.45	90.47
0.49	5.464	95.93			

The rotation matrix is shown in (table V), the per capita disposable income, household consumption level, vegetable yield and permanent resident population have high loads in the second common factor F1, per capita disposable income of residents, household consumption level, indicator reflects the residents' income and consumption ability, vegetable production reflects the supply, the permanent resident population reflects the demand for vegetables, so it is difficult to define F1, eventually be named the mixed factor; agricultural production goods index, semi mechanized farm tools production goods price index, mechanized farming tools production goods price index, chemical fertilizer production goods price index have high loads in the first common factor F2, basically reflects the production cost, so the F2 can be called the production cost factor.

TABLE V.
FACTOR LOADING MATRIX AFTER ROTATION

	F1	F2
Agricultural production goods index	0.02	0.96
Semi mechanized farm tools production data price index	0.04	0.90
Mechanized farming tools production goods price index	0.14	0.95
Chemical fertilizer production goods price index	-0.08	0.92
Per capital disposable income of residents	0.99	0.06
Household consumption level	0.97	0.04
Disaster rate	-0.82	-0.34
Vegetable yield	0.95	-0.16
Permanent resident population	0.99	-0.05

4. Factor score

According to the factor scoring sequence, the scoring of F1 and F2 in each year from 1995 to 2015 (as shown in Figure5) shows intuitively that the fluctuation of vegetable prices in different years is emphasized by various factors.

(1) During 1995-1998, 2001-2002, 2011-2014, F2 factor had significant influence on vegetable price fluctuation in Hebei province. In these periods, the factors of vegetable price fluctuation in Hebei province were mainly driven by cost, and the reduction of the different costs resulted in a great drop in vegetable prices.

(2) From 2011 to 2012, F1 factor had significant influence on vegetable price fluctuation in Hebei province. From 2011 to 2012, the consumption level of Hebei residents, per capita disposable income increased, purchasing power increased, the demand for vegetables increased, and the demand for vegetables led to the rise in prices.

(3) During 2003-2004, 2007-2008, F1, F2 factor interaction effect was significant on vegetable prices in Hebei. During this period, vegetable production costs and the increasing demand for vegetables have stimulated vegetable prices.

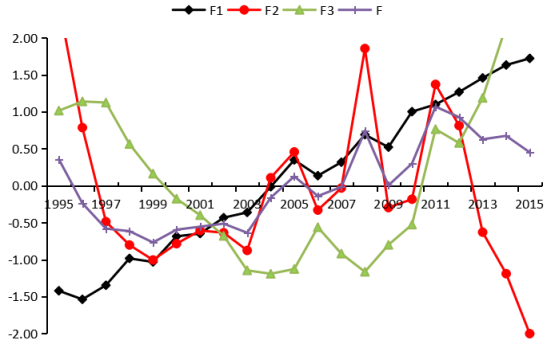

Figure 5: 1995-2015 factor score and vegetable consumption price index distribution

5. Factor analysis conclusion

The results show that the main influencing factors of Hebei vegetable prices fluctuations since 1995 were the production cost factor, purchasing ability, population and other factors, each factor has great difference in different time influence on the size and orientation of the fluctuations in the price of vegetables(Robert,2006).

C. Vector autoregressive (VAR) model

Through factor analysis that main factors influencing Hebei Province vegetable price fluctuation are production cost, the purchasing power, population and other factors, in the VAR model construction process, factors of more representative under each common index were selected into the model, the influence degree of each price fluctuation factors were carried out quantitative treatment(Shen,2015).With each factor loading value is higher for the selection criteria, ultimately included in the VAR model index for agricultural production goods index (X1), mechanized farm production goods price index (X2), per capita disposable income (X3) and permanent resident population (X4).

In order to eliminate the possible heteroscedasticity of time sequence data, the logarithm of the data sequence is taken [5].

1. ADF test

In the process of fitting the model, the pseudo regression will appear in the non-stationary sequence, to judge whether the cointegration relationship exists between variables, ts, the augmented Dickey–Fuller test (ADF) was used for stationarity or trend-stationarity,test

of the sequences, the lag period and test form are determined under the precise of AIC criterion - Akaike information criterion, SC criterion - Schwartz criterion, DW values are relatively good.Find: Extracted information shows that the vegetable consumer price index (LNY), agricultural production goods index (LNX1) and mechanized farming production goods price index (LNX2) are stationary sequences, per capita disposable income (LNX3) and permanent resident population (LNX4) are non stationary sequences, in order to guarantee the validity of the VAR model, the first order difference were made to all sequences, after that are stationary sequences, so the visual sequence is I (1) integration, which can be tested by Johansen cointegration test.

2. Johansen test

Johansen test is a method based on VAR model to test regression coefficient proposed by Johansen together with Juselius in 1988 and in 1990, is a multivariate cointegration test method, used to determine whether a long-term equilibrium relationship exists between the sequences.It is found through inspection that there are two long-term cointegration relationships at the 5% significance level.

3. Stability test of VAR model

The construction of the VAR model is not required for the smoothness of the sequence. In order to ensure the interpretability of the result, this paper builds the model for the logarithm of index data [6]. According to the AIC criterion and the SC criterion, the period 2 was determined as lag period, the VAR model is established:

LNY=-0.520639LNY(-1)-0.529812LNY(-2) -0.742414LNX1(-1) -0.374391 LNX1(-2)+ 1.967182 LNX2(-2)+0.705089 LNX2(-2)+ 0.782599 LNX3(-1) -0.304461 LNX3(-2) -3.759376 LNX4(-1) -2.485596 LNX4(-2)

The premise of impulse response function and variance decomposition is that the VAR model must be stationary. As shown in(figure 6), the root model is within the unit circle, and the VAR model has stability, which can be carried out impulse response and variance decomposition.

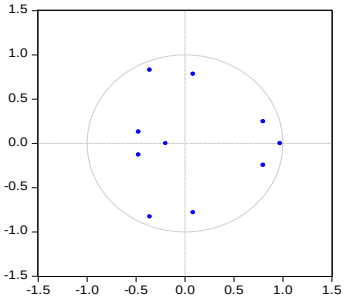

Figure 6: unit circle of AR characteristic root

C. Impulse response

The impulse response function reflects the impact of an endogenous variable in the VAR model on other endogenous variables (as shown in Figure 7).

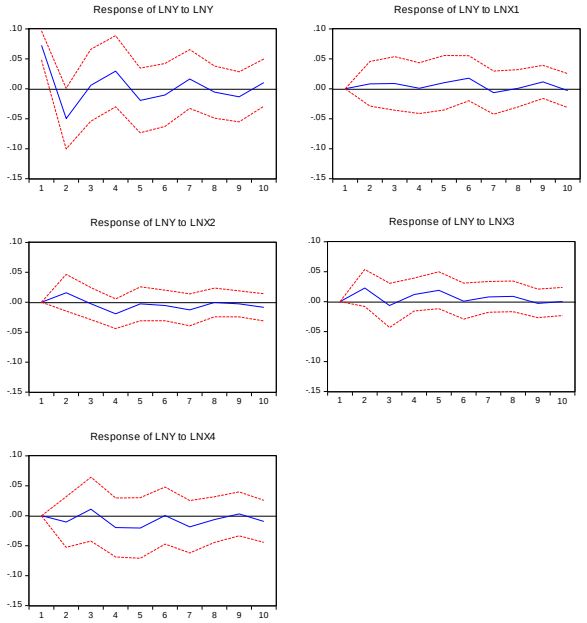

Figure 7: impulse response analysis diagram

Figure 7 is analyzed:

(1) This period gives the vegetable consumer price a positive impact, causing 0.072% of the positive impact on itself, and then rapidly decay, reached the lowest point (-0.05%) at the second phase, the third, fourth stage began to pick up, basically showing a "V" cycle with 4 cycles as a cycle, but the impact gradually weakened.

(2) The start value of the impact of other indicators on vegetable consumption prices all are 0, and then, in addition to the permanent resident population, the forces of other factors began to rise, began to fall after the period 1, the cycle is basically cycle 3 or 4, but the impact force is relatively small and fluctuates around 0.

5. Variance decomposition

Variance decomposition is to analyze the contribution of each structural shock to endogenous variables (usually measured by variance), and further find out the importance of each factor to the fluctuation of vegetable prices in Hebei province. (As shown in Table 6), the influence weighting coefficient matrix of each factor on vegetable price fluctuation in Hebei Province in the 6 lag periods, and the weight coefficient of each row are both 100. The greater the value, the greater the impact of a factor on vegetable prices during the period.

TABLE VI.
CONTRIBUTION OF VARIOUS FACTORS TO VEGETABLE PRICE FLUCTUATION.

Period	S.E.	LNY	LNX1	LNX2	LNX3	LNX4
1	0.07	100.00	0.00	0.00	0.00	0.00
2	0.09	89.18	0.77	2.87	5.91	1.27
3	0.09	86.77	1.62	2.85	6.21	2.55
4	0.10	80.50	1.36	5.86	6.48	5.80
5	0.11	75.17	2.06	5.30	8.78	8.69
6	0.11	73.33	4.48	5.33	8.47	8.38

Table 6 shows that the vegetable price fluctuation is

mainly affected by itself, and the standard deviation at the beginning is completely self bearing, and the carrying capacity is still up to 68% until the 12 stage. The influence degree of various factors on vegetable price fluctuation is from top to bottom permanent resident population, per capita disposable income, mechanization farm tools production goods price index and agricultural production goods index. As time goes on, the influence of various factors on vegetable price fluctuation is also gradually obvious.

IV. Conclusion

A. The vegetable price fluctuation of Hebei Province has an obvious seasonal character

The vegetable price fluctuation of Hebei Province has an obvious seasonal character. The annual consumption price index of vegetables shows a "W"-shaped violent fluctuation; vegetable monthly consumption price index shows a "V"-shaped fluctuation situation, the price of vegetables remained high at the beginning of the year, but it began to fall in February and March until it reached the lowest level in June and July; then it gradually rebounded later, the price in December to March of the following year then rose to the commanding height of the whole year(Chapman,2005).Overall,the price of vegetables in Hebei Province shows a clear upward trend in volatility.

B. The vegetable price fluctuation of Hebei Province has obvious periodicity

The monthly consumer price index of Hebei Province was divided into three cycles. The average period of the fluctuation period is 26 months, and it is a long-term fluctuation; the fluctuation amplitude is high and it is a kind of large fluctuation. The expansion period is shorter than the systolic period volatility is relatively high, is a strong volatility; expansion period is shorter than the systolic period, the price decline is persistent. The period type belongs to the classical style. In general, since 2009, Hebei Province's vegetable consumption price index has experienced substantial volatility, relatively stable and sharp volatility. For different periods, vegetable price fluctuations have a difference in duration and volatility degree.

C. Main influencing factors of vegetable price fluctuation in Hebei Province

Through the factor analysis, it is found that since 1995 in Hebei Province, main factors affecting the vegetable prices fluctuation are production cost, purchasing power, population, various factors have great difference in different time influence on the size and orientation of the vegetable prices fluctuation.

The more representative indexes under common factors is taken into the VAR model, the results showed that agricultural production goods index, mechanized farming production goods price index, per capita disposable income of residents and permanent resident population are relatively small impact on the vegetable prices, cyclically changes; vegetable price fluctuations are mainly affected by their own, and with the time goes on, the contribution of various factors to the vegetable prices fluctuation in Hebei province is increasing.

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