Construction and Empirical Study of Agricultural Product Price Index: Post-print

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Abstract

[Purpose/Significance] China is a major agricultural nation, and the stability of agricultural product prices directly determines China' s economic development. The compilation of agricultural product price indices is of significant importance for establishing and perfecting the agricultural product price index system, allowing various stakeholders to intuitively comprehend the development status of agricultural product markets, and elevating the level of market monitoring and early warning. [Method/Process] Grounded in current research findings on agricultural product prices and price indices, this study examines and discusses the principles of agricultural product price index construction, the framework of the agricultural product price index system, index classification and gradation, measurement models, and weight determination methods, and conducts an empirical study on agricultural product price index construction based on statistical and survey data. [Results/Conclusion] Empirical results indicate that the framework of the agricultural product price index system and the approach to index classification and gradation are rational, and that the index measurement models and weight determination methods are scientifically sound and feasible. This not only enriches and refines the theory and methodology of agricultural product price index system construction, but the established Beijing agricultural product wholesale price series index also actively contributes to the monitoring and early warning of Beijing' s agricultural product market operations, the enhancement of agricultural product brand influence, and the implementation of agricultural insurance.

Full Text

Preamble

Title: Construction and Empirical Study of Agricultural Product Price Indices

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Abstract:
[Purpose/Significance] China is a major agricultural country, and the stability of agricultural product prices directly determines China' s economic development. Developing agricultural product price indices is significant for establishing a sound agricultural product price index system, enabling participants to intuitively understand the development status of the agricultural product market, and improving market monitoring and early warning capabilities. [Method/Process] Based on current research findings on agricultural product prices and price indices, this study explores the principles of constructing agricultural product price indices, the framework of the agricultural product price index system, index classification and grading, calculation models, and weight determination methods. An empirical study on the construction of agricultural product price indices was conducted using statistical data and research data. [Results/Conclusions] Empirical results indicate that the framework and classification of the agricultural product price index system are reasonable, and the index calculation model and weight determination method are scientifically feasible. This not only enriches and improves the theory and methods for constructing agricultural product price index systems but also forms the Beijing agricultural product wholesale price series index, which plays a positive role in monitoring and early warning of Beijing' s agricultural product market operations, enhancing agricultural product brand influence, and implementing agricultural insurance.

Keywords: price index; model; agricultural products; Beijing; digital economy
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1 Introduction

China is a major agricultural country, and the stability of agricultural product prices is closely related to economic and social development. Price fluctuations of agricultural products, especially fresh agricultural products, and market instability have become significant challenges facing China' s agricultural industry development. Indices are widely used in various fields of social and economic operation, simplifying complex problems by representing them with concise numbers, and have formed numerous index products such as commodity price indices, transportation indices, and industry prosperity indices, providing intuitive and convenient decision-making references for social economic operation and people' s lives. As agricultural product prices and various monitoring networks and systems continue to develop and improve, data information is

becoming increasingly abundant and improved in both quantity and quality. Agricultural product price indices, as important economic indicators reflecting the operational trends and fluctuation degrees of agricultural product markets during certain periods, play a crucial role as barometers, weather vanes, and lightning rods for analyzing and predicting agricultural economic development and agricultural product market operations. Academic research on agricultural product price indices mainly involves two aspects: first, the compilation of agricultural product trade price indices, such as the WTO' s ITS, which explains the calculation process of global agricultural product foreign trade price indices, and the Ministry of Commerce' s full-sample index based on the Paasche formula; second, research on agricultural product wholesale price indices, such as Cheng Shifu et al.' s proposal to use base-period rolling weights to compile fresh vegetable wholesale price indices, and Shi Bowen' s use of the Laspeyres index to compile a national aquatic product wholesale price index. Based on these research foundations, China has compiled and released various comprehensive or single-item price indices related to agricultural products, including the important agricultural product production price index released by the National Bureau of Statistics, the agricultural product wholesale price 200 index released by the Ministry of Agriculture and Rural Affairs, and characteristic single-item indices such as the Shouguang Vegetable Price Index, China Strawberry Industry Changping Index, China Zunyi Chaotianjiao Index, and Yantai Apple Price Index. At the local level, there are indices such as the Shandong Vegetable Price Index. The construction of agricultural product price indices not only helps the agricultural industry move toward digitalization and creates brand images for market entities but also effectively helps the government accurately grasp price change trends, fluctuation patterns, and transmission mechanisms of agricultural products, enabling monitoring and early warning of market price anomalies and providing a basis for macroeconomic regulation and decision-making.

2.1 Basic Principles

The compilation of agricultural product price indices should follow three basic principles: scientificity, comprehensiveness, and practicality. **Scientificity** is mainly reflected in two aspects: first, basic price data should be comprehensive and true, scientifically reflecting price fluctuations; second, index compilation methods should select effective technical models according to different index types. **Comprehensiveness** means that agricultural product price index construction is a systematic project that should fully consider the authority of agricultural product classification, the scientificity of the index system, the rationality of base period selection, the accuracy of weight setting, and the authenticity of data acquisition. **Practicality** means that agricultural product price index construction should objectively reflect changes in agricultural product wholesale market conditions, guide farmers or enterprises to grasp market trends, optimize business strategies, adjust production scales, regulate market transaction price order, form industry price self-discipline mechanisms, and provide a basis for

government macroeconomic regulation and decision-making.

Currently, constructing comprehensive price indices is mainly based on two basic theories: the Laspeyres index and the Paasche index. The Laspeyres index uses base-period weights, which can eliminate the impact of weight changes on the index, making price indices of different periods comparable. However, it can only reflect price changes and cannot reflect the impact of quantity structure changes, such as the Consumer Price Index (CPI). The Paasche index, also known as the reporting-period weighted index, uses reporting-period weights as the calculation basis. The Paasche index cannot eliminate the impact of weight changes on the index, making indices of different periods less comparable, but it can simultaneously reflect changes in prices, quantities, and structures, such as the GDP deflator. Both methods have their advantages and disadvantages, and the choice should be based on specific needs.

2.2 Classification and Grading of Agricultural Product Price Indices

The design of the agricultural product price index system needs to consider three major dimensions: variety classification, time period, and geographical region. Variety classification determines the categories of price indices, time period determines the granularity of price indices, and geographical region determines the levels of price indices. The agricultural product price index system is shown in [Figure 1: see original paper].

From the perspective of variety classification, agricultural product price indices are divided into six categories: The first category is the overall agricultural product price index, which comprehensively reflects the price operation of agricultural products in the wholesale market. The second category is the fresh agricultural product price index, which mainly reflects the price operation of fresh agricultural products. The third category includes five major categories: vegetables, fruits, meat/poultry/eggs, aquatic products, and grain/oil, reflecting the respective price operations of these five categories. The fourth category is the sub-category agricultural product price index, reflecting the price operation of each sub-category. The fifth category is the large-variety agricultural product price index, reflecting the price operation of large varieties such as leafy vegetables, root vegetables, and meat. The sixth category is the single-variety agricultural product price index, reflecting the price operation of single varieties such as cabbage and chicken.

From the perspective of index levels, agricultural product price indices are divided into three levels: municipal, district/county, and individual wholesale markets, meeting the needs of different regions for agricultural product price indices. From the time dimension, agricultural product price indices include daily, weekly, monthly, quarterly, and annual indices, forming a complete time dimension.

2.3 Determination of Varieties in Agricultural Product Price Indices

The agricultural products collected from wholesale markets mainly include five major categories: vegetables, fruits, meat/poultry/eggs, aquatic products, and grain/oil. The selection of varieties included in the price index construction follows the principles of large market consumption and circulation volume, and year-round market supply to ensure the continuity of index construction. The instability of selected varieties would impact the price index, so the variety directory should eliminate the impact of unstable varieties on the price index while truly reflecting and matching market changes.

2.4 Agricultural Product Price Index Model

In constructing agricultural product price index models, the advantages of both Laspeyres and Paasche price indices should be fully absorbed and utilized. For varieties with large market volume fluctuations and their major categories, such as vegetables containing many varieties with significant seasonal impacts and large changes in market volume across different time periods, the Paasche index theory should be used for model construction. For comprehensive price indices where the consumption of major categories is generally stable and balanced, the fixed-base principle of the Laspeyres index should be used for model construction.

The calculation formula for categories with large market volume fluctuations is as follows: indu represents the comprehensive agricultural product price index of each wholesale market. p_0 represents the base-period wholesale market price of agricultural product i, p_1 represents the reporting-period wholesale market price of agricultural product i, and q_1 represents the reporting-period market volume of agricultural product i in each wholesale market. t_0 and t_1 represent the base period and reporting period, respectively. p_{0} represents the daily price of a certain variety at each monitoring point in the base period, q_{0} represents the daily market volume of a certain variety at each monitoring point in the base period, p_{1} represents the daily price of a certain variety at each monitoring point in the reporting period, and q_{1} represents the daily market volume of a certain variety at each monitoring point in the reporting period. j represents different monitoring points, and the formula uses the number of days required for different dimensions based on the base period and reporting period.

For comprehensive price indices, the calculation formula is: Ind represents the overall price index, indu represents the comprehensive category indices, and ω represents the relatively fixed weights of each comprehensive category of agricultural products.

2.5 Determination of Weights for Various Levels of Indices

The weights for the Beijing agricultural product price index and fresh agricultural product price index are determined using a comprehensive method. Since these indices reflect more macro-level situations and comprehensively reflect price changes of agricultural products traded in wholesale markets, and given that consumption of major categories of agricultural products is relatively stable, the fixed-base method is used for weight determination. The key is the determination of ω .

3.1 Establishment of Agricultural Product Variety Directory

There are more than 870 single varieties of agricultural products circulating in Beijing' s wholesale markets. Following the principles of large market volume and year-round supply to ensure index continuity, data from 2002 to 2013 were used as reference. Among the five major categories, 77 vegetable varieties were selected, accounting for 97.3% of total vegetable market volume; 28 fruit varieties, accounting for 83.3% of total fruit market volume; 14 meat/poultry/egg varieties, accounting for 63.7% of total meat/poultry/egg product market volume; 37 aquatic product varieties, accounting for 86.2% of total aquatic product market volume; and 19 grain/oil varieties, accounting for 29% of total grain/oil market volume. Considering that grain/oil products are mainly retail products, branded Northeast rice, flour, and salad oil with large transaction volumes were selected to represent market changes. A total of 175 single varieties were determined, accounting for 20.1% of the total number of varieties but representing 63.7% of total market volume, with strong representativeness.

3.2 Determination of Various Agricultural Product Price Index Indicators

As shown in [Figure 1: see original paper] and Section 2.2, the Beijing agricultural product price index and fresh agricultural product price index are both composite indices. The Beijing fresh agricultural product price index includes vegetables and aquatic products, while the Beijing agricultural product price index includes vegetables, fruits, meat/poultry/eggs, aquatic products, and grain/oil. The Beijing five-category agricultural product price index contains five indicators: Beijing vegetable price index, fruit price index, meat/poultry/egg price index, aquatic product price index, and grain/oil price index. The Beijing single-variety agricultural product price index contains 175 indicators.

According to the classification in Section 2.2, the weights for the third to sixth categories of agricultural product price indices are determined based on the market volume of each variety during the reporting period in the wholesale market. The weights for the first and second categories of agricultural product price

indices are determined using a comprehensive method, with per capita consumption expenditure data as the benchmark, combined with vegetable consumption research data and comprehensive comparison of market volume and value.

3.2.1 Sub-category Agricultural Product Price Index Indicators

Sub-category agricultural product price index indicators are determined based on the morphological characteristics and edible parts of agricultural products. Vegetables are divided into 10 sub-category indicators: leafy vegetables, cabbage, root vegetables, eggplant fruits, melons, beans, edible fungi, aquatic vegetables, Allium vegetables, and other vegetables. Fruits are divided into 6 subcategory indicators: pome fruits, citrus fruits, watermelon/melon, tropical fruits, berries, and stone fruits. Meat/poultry/eggs are divided into 2 sub-category indicators: meat and eggs. Aquatic products are divided into 2 sub-category indicators: freshwater fish and seawater fish. Grain/oil is divided into 2 subcategory indicators: grains and edible oils. In total, the Beijing sub-category agricultural product price index includes 22 indicators.

3.2.2 Beijing Large-Variety Agricultural Product Price Index Indicators

Large-variety agricultural product price index indicators follow the principle of large market volume and year-round supply. Based on data from 2002 to 2013, 43 large-variety indicators were selected. Vegetable products include 18 large-variety indicators: cabbage, other leafy vegetables, root vegetables, other Allium vegetables, etc. Fruit products include 10 large-variety indicators: watermelon, other tropical fruits, other berries, etc. Meat/poultry/egg products include 4 large-variety indicators. Fish products include 11 large-variety indicators: grass carp, other seawater fish, etc. Grain/oil products include 3 large-variety indicators: rice, flour, and salad oil.

3.3 Determination of Weights for Various Agricultural Product Price Indices

3.3.1 Determining Weights for Major Categories Based on Market Volume or Value

Two approaches were compared for determining weights. Using market volume as weights means the price index assigns weights based on residents'consumption volume of major agricultural product categories. In this approach, vegetables and fruits have large weights, while grain/oil has a significantly smaller weight. After index processing, the impact of vegetables and fruits on the final price index is amplified, while the impact of other agricultural product price changes is diminished.

Using market value as weights means the price index assigns weights based on residents' expenditure on major agricultural product categories. Market value

better represents residents' consumption expenditure on various agricultural products in Beijing and provides more balanced weights compared to market volume, though vegetables still have a relatively large proportion that may affect index reflection.

3.3.2 Based on Beijing Municipal Bureau of Statistics Data on Major Agricultural Product Consumption Expenditure

Since the Beijing Municipal Bureau of Statistics began merging meat/poultry/egg and aquatic product consumption expenditure data from 2013, and also merged fruit consumption expenditure into dried and fresh fruits, this study considered both methodological and empirical research perspectives. Using 2011-2012 per capita agricultural product expenditure as reference data, the proportion of meat/poultry/eggs increased significantly while the proportion of vegetable expenditure decreased noticeably, though this was still an improvement over using market volume weights.

3.3.3 Determination of Weights for Major Categories of Agricultural Products

The final weights for major categories of agricultural products were determined by comprehensively considering the above methods. As vegetables are the most consumed variety and the most important for ensuring stable production and supply, this study appropriately adjusted the vegetable weight based on vegetable consumption research data from the Beijing Digital Agriculture Rural Promotion Center in 2012. The per capita vegetable consumption expenditure was 984 yuan in 2011 and 1,117 yuan in 2012. Using this data, the vegetable weight was adjusted to be slightly lower than the current proportion. The final weight results are shown in .

The weights for Beijing' s five-category agricultural product price index, subcategory agricultural product price index, large-variety agricultural product price index, and single-variety agricultural product price index are all based on the market volume of each variety during the reporting period in the wholesale market, as detailed in and .

4 Conclusion

Based on the demand for agricultural product market information services, this study conducted research on agricultural product price index construction and empirical analysis. Drawing on existing research results, the study clarified the basic principles of agricultural product price index construction, built an agricultural product price index system framework, and focused on solving three key technical issues: the classification of wholesale market agricultural product price indices, the determination and classification of agricultural product varieties, and the weight determination methods for different categories of price

indices. Taking Beijing' s agricultural product price index construction as an example, the study conducted research and creation of Beijing' s wholesale market agricultural product price series indices and developed software-based models for batch generation of indices at various levels. The research results not only enrich and improve the theory and methods of agricultural product price index system construction but also provide useful references for improving agricultural product price index systems and index compilation work. The formed Beijing agricultural product wholesale price series index plays a positive role in monitoring and early warning of Beijing' s agricultural product market operations, enhancing agricultural product brand influence, and implementing agricultural insurance.

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Note: Figure translations are in progress. See original paper for figures.