Research on E-Commerce Product Quality Monitoring Sampling Method

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Abstract. This paper researches the features of quality monitoring sampling of E-commerce products, analyzes the current status of development of E-commerce industry, and proposes an E-commerce product quality monitoring sampling survey method on the basis of the research on the existing E-commerce product quality monitoring literatures and standards from the perspective of mastering the overall quality situation of the category of products sold through E-commerce channels, and the contents include the determination of quality monitoring object and quality characteristics as well as the determination of the monitoring total and the construction of the sampling frame and sampling method, etc. This method is applicable to the estimation of product quality level of the monitoring total as discrete individual products or quantitative packaged bulk materials and provides theoretical and technical supports for the work of quality monitoring sampling of E-commerce products in our country.

1. Introduction

In recent years, the E-commerce industry develops rapidly in our country, with the E-commerce transaction scale continuing to expand and maintaining a high-speed growth state. As shown by the data of National Bureau of Statistics, in 2017, the nationwide E-commerce transaction amount reached 29.16 trillion Yuan, and the online retail sales reached 7.18 trillion Yuan. Online shopping has become an important way of consumption, however, the commodity quality problems of online shopping are increasingly prominent [1]. The online shopping consumers are often troubled by quality problems of the three-non products, counterfeit and shoddy products, nonconforming products, etc. that occur frequently. It is particularly urgent to carry out and strengthen the work of quality monitoring of E-commerce products. The quality monitoring of E-commerce products is a sampling survey process carried out to master the overall quality level of E-commerce products and estimate the overall parameters through the sampling survey.

The product quality monitoring sampling survey is an important means to carry out the quality supervision in E-commerce environment, and the scientificness and operability are the keys to the sampling part. As there are many differences between the quality monitoring of E-commerce products and the quality monitoring of physical store commodities or warehouse products, it is urgent to reseach the method of quality monitoring sampling of E-commerce products to effectively promote the healthy development of E-commerce industry in our country.
2. Research on the existing E-commerce product quality monitoring literatures and standards
The domestic academic circle has largely explored the quality situation of E-commerce products, but has less researched the E-commerce product quality monitoring sampling methods. From the perspective of product quality supervision mode, He Yunfu pointed out that all the acquisition, confirmation, subsequent processing parts, etc. of the samples needed by the supervision sampling of E-commerce products are different from the situations encountered in routine supervision sampling work [2] and also discussed the supervision sampling mode of E-commerce products, but the product quality monitoring sampling method was not involved. Starting from the protection of the interests of consumers, Song Mingshun proposed the sampling plan parameter setting model in combination with Poisson distribution model and summarized the procedure for the formulation of E-commerce product quality supervision sampling plan [3], while this plan proposed a primary sampling plan design method for quality supervision and counting of non-warehouse E-commerce products which has high reference value for the formulation of continuous supervision sampling plan of non-warehousing E-commerce products.

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At present, our country has issued the GB/T 28863-2012 Sampling Inspection Procedures for Commodity Applying to the Case with Prior Information of Quality (hereinafter referred to as CB/T 28863-2012) and GB/T 2828 series standards which specify the methods of quality supervision sampling of commodities in circulation domain. However, the statistics of CB/T 28863-2012 and GB/T 2828 series standards are based on hypothesis test, in which, the quality parameters of the inspected products are known, the sampling inspection is carried out to verify whether these quality parameters are true, but it is impossible to make an inference for the overall quality. GB/T 2828 series standards are mainly used for acceptance and reject tests of batch products and are applicable to the production process quality control or the finished product test, and the quality parameters of the tested products are required to be relatively stable. While although the products sold on E-commerce platform are consistent in quality and performance indicators, they may be from different manufacturers and don't have uniform quality parameters, therefore, GB/T 2828 series standards are not applicable to the risk monitoring of quality of E-commerce products.

The method specified in GB/T 28863 is the sampling inspection based on prior information of quality, which is a targeted sampling inspection of the products that may have problems, for the purpose of finding the products with quality problems and taking administrative penalty measures; this method provides the sampling method, sampling plan and evaluation procedure for quality supervision of quality characteristics of commodities in circulation domain and is only used to determine that a certain supervision total does not conform to a certain quality requirement, it is not used to determine that a certain supervision total conforms to a certain quality requirement, nor can it achieve the purpose of risk monitoring of quality of E-commerce products. Therefore, this paper will research the E-commerce product quality monitoring sampling method.

3. E-commerce Product Quality Monitoring Sampling Method
This paper researches the E-commerce product quality monitoring sampling survey method from the perspective of mastering the overall quality situation of the category of products sold through E-commerce channels, which includes the determination of quality monitoring object and quality characteristics as well as the determination of the monitoring total and the construction of the sampling frame and sampling method, etc.

3.1. Determination of Quality Monitoring Object and Quality Characteristics
A certain category (or a certain kind) of products is determined as the quality monitoring object. For the determined quality monitoring object, the quality indicators which can reflect the quality situation
of this category (or kind) of products are selected as the quality characteristics of the quality monitoring object. One or more quality characteristics of a certain category (kind) of products can be inspected in a quality monitoring process. The quality monitoring object can be a category of products (such as toys) or a kind of products (such as plush toys), and their quality characteristics are determined respectively according to the quality monitoring; as the quality characteristics of different samples of products may have differences, the inspection result only judges whether they are conforming or not.

3.2. Determination of the Monitoring Total and Construction of the Sampling Frame

3.2.1. Determination of the Monitoring Total. The monitoring total of E-commerce products is determined according to the following steps:
(1) One or more E-commerce platforms are selected according to the determined quality monitoring object.

(2) The search keywords related to the quality monitoring object and quality characteristics are set on the selected E-commerce platform; the combination of search keywords shall include the scientific name, common name, etc. of the products, and all the relevant sale links shall be collected. When the relevant sale links can't be collected by search, the necessary sale link information shall be obtained by other means.

(3) The sale links are processed to eliminate the duplicate links, abnormal price links and other invalid sale links that don't conform to the quality monitoring object and quality characteristic requirements.

(4) All the products in sale corresponding to all the valid sale links are considered as the monitoring total.

3.2.2. Construction of Sampling Frame. All the sale links are arranged into a directory as the sampling frame.

3.3. Sampling Method

The purpose of E-commerce product quality monitoring sampling is to make an inference for the overall quality situation of this category of products through the inspection of a certain number of samples that are selected randomly. Therefore, in order to keep consistent with the actual consumption conditions, the selection of samples adopts the simple random sampling method [5, 6].

3.3.1. Determination of Number of Samples. The samples shall be the products sold on the E-commerce platform. Considering the objective demand for the precision of estimation of overall quality level of E-commerce products and the comparability of the overall quality level estimations obtained at the time of consolidation of different relevant parties using this method, the number of samples is determined according to the following steps.
(1) Pre-estimation of Prior Nonconformity Rate

For the determined monitoring sampling inspection object and quality characteristics, the obtained product quality information is fully utilized to pre-estimate the overall prior nonconformity rate. If it is impossible to pre-estimate the overall prior nonconformity rate, the prior nonconformity rate shall be considered as 50% for use in the processing.

(2) Determination of Overall Estimation Reliability and Precision

The confidence level and error precision limit of the estimate of overall quality level of the monitoring total is determined according to the requirements for the quality of monitoring results. For the determination of confidence level and absolute error limit, appropriate adjustment can be made according to the factors such as the empirical data of previous survey experience and the importance of quality level of survey object.

(3) Determination of Number of the Monitoring Total
The sum of the numbers of products in sale corresponding to all the sale links constitutes the number of the monitoring total. If a sale link does not have the information about the number of the products in sale, the number of the monitoring total shall be considered as being infinitely large.

(4) Determination of Number of Samples

The number of samples is calculated by the following method on the basis of the determined number of the monitoring total, the pre-estimated prior nonconformity rate, the determined confidence level and absolute estimation error.

Step 1: See (1) for the formula for calculating the initial number of samples:

$$n' = \frac{(u_{1-\alpha/2})^2 p(1 - p)}{\varepsilon^2}$$  \hspace{1cm} (1)

Where:

- \(N'\) —— Initial number of samples;
- \(P\) —— Prior estimate of overall nonconformity rate;
- \(1-\alpha\) —— Confidence level;
- \(u_{1-\alpha/2}\) —— fractile of standardized normal distribution;
- \(\varepsilon\) —— Absolute error limit of nonconformity rate estimation of products.

Step 2: The number \(N\) of the monitoring total is used to modify, and the final number of samples is obtained, see (2) for the formula for calculating the number of samples:

$$n = n'\times \frac{N}{N + n'}$$  \hspace{1cm} (2)

- \(n\) —— Number of samples;
- \(N\) —— Number of the monitoring total.

For the general survey, Table 1 provides the numbers of samples in the cases with different prior nonconformity rates when the confidence level of the estimate of overall quality level is 95% and the absolute error limit of the estimate is 3% for the users to look up in the table for reference. The number of samples provided in Table 1 is for reference only in the cases where there is no special requirement for survey results and estimation precision; if the number of samples in the case with more special requirements is to be obtained, it shall also be calculated according to Formula (1) and Formula (2).

3.3.2. Sampling. The sampling is carried out in the sampling frame according to the simple random sampling method:

(1) All the sale links in the sampling frame are numbered in sequence.

(2) If the number \(n\) of samples is less than the total number \(L\) of valid sale links, \(n\) sale links shall be selected randomly from the sampling box; if the number \(n\) of samples is larger than or equal to the total number \(L\) of valid sale links, first, all the \(L\) sale links shall be selected for \([n/L]\) times, then, \(n-[n/L]\) sale links shall be selected randomly from the sampling box, where \([n/L]\) represents the maximum integer not larger than \(n/L\).

(3) For any sale link that is selected randomly, one or more products shall be selected randomly as one or more samples according to the product inspection requirements.

When selecting the samples, the attention shall be paid to two aspects:

(1) Through the identity of mysterious buyer, the samples are bought in sequence from the generated \(n\) sale links until \(n\) samples are bought. In the case of failure to obtain the samples after the buying, the sale links shall be selected randomly from the remaining sale links according to the simple
random sampling method proposed above, and the supplementary samples shall be selected from the sale links.

(2) The samples obtained by online shopping shall be confirmed. In the case that the samples obtained by online shopping fail to conform to the monitoring object and quality characteristic requirements, the supplementary samples shall be selected randomly from the remaining sale links.

Table 1. Table for Looking Up the Number of Samples.

| N       | P =5% | P =10% | P =20% | P =30% | P =40% | P =50% |
|---------|-------|--------|--------|--------|--------|--------|
| (0, 100 ] | 67    | 80     | 88     | 90     | 92     | 92     |
| (100, 200 ] | 101   | 132    | 155    | 164    | 168    | 169    |
| (200, 300 ] | 122   | 169    | 209    | 225    | 233    | 235    |
| (300, 400 ] | 135   | 196    | 253    | 277    | 288    | 291    |
| (400, 500 ] | 145   | 218    | 289    | 321    | 336    | 341    |
| (500, 600 ] | 152   | 235    | 320    | 360    | 379    | 385    |
| (600, 700 ] | 158   | 248    | 346    | 393    | 416    | 423    |
| (700, 800 ] | 162   | 260    | 369    | 423    | 450    | 458    |
| (800, 900 ] | 166   | 270    | 388    | 449    | 480    | 489    |
| (900, 1000 ] | 169  | 278    | 406    | 473    | 506    | 517    |
| (1000, 2000 ] | 185  | 323    | 509    | 619    | 678    | 696    |
| (2000, 3000 ] | 191  | 341    | 556    | 690    | 764    | 788    |
| (3000, 4000 ] | 194  | 351    | 583    | 733    | 816    | 843    |
| (4000, 5000 ] | 196  | 357    | 601    | 760    | 850    | 880    |
| (5000, 6000 ] | 197  | 361    | 613    | 780    | 875    | 906    |
| (6000, 7000 ] | 198  | 365    | 622    | 795    | 894    | 926    |
| (7000, 8000 ] | 198  | 367    | 629    | 806    | 908    | 942    |
| (8000, 9000 ] | 199  | 369    | 634    | 815    | 920    | 954    |
| (9000, 10000 ] | 199  | 370    | 639    | 823    | 929    | 965    |
| (10000, 20000 ] | 201  | 377    | 660    | 858    | 975    | 1013   |
| (20000, 30000 ] | 202  | 380    | 667    | 871    | 991    | 1031   |
| (30000, 40000 ] | 202  | 381    | 671    | 877    | 999    | 1040   |
| (40000, 50000 ] | 203  | 382    | 673    | 881    | 1004   | 1045   |
| (50000, 60000 ] | 203  | 382    | 675    | 883    | 1007   | 1049   |
| (60000, 70000 ] | 203  | 382    | 676    | 885    | 1010   | 1051   |
| (70000, 80000 ] | 203  | 383    | 677    | 887    | 1012   | 1053   |
| (80000, 90000 ] | 203  | 383    | 677    | 888    | 1013   | 1055   |
| (90000, 100000 ] | 203  | 383    | 678    | 889    | 1014   | 1056   |
| (100000, 200000 ] | 203  | 384    | 680    | 893    | 1019   | 1062   |
| (200000, 300000 ] | 203  | 384    | 681    | 894    | 1021   | 1064   |
| (300000, 400000 ] | 203  | 384    | 681    | 894    | 1022   | 1065   |
| (400000, 500000 ] | 203  | 384    | 682    | 895    | 1022   | 1065   |
| >500000 ] | 203   | 385    | 683    | 897    | 1025   | 1068   |
3.3.3. Sample Inspection. The paper represents the product quality level of the monitoring total by using the point estimate and confidence interval value of the overall nonconformity rate (or the overall conformity rate).

3.3.4. Result Calculation This paper represents the product quality level of the monitoring total by using the point estimate and confidence interval value of the overall nonconformity rate (or the overall conformity rate).

See (3) for the formula for calculation of point estimate of overall nonconformity rate:

\[
\hat{p} = \frac{d}{n} \times 100\%
\]

\(d\) —— Number of non-conforming samples;
\(n\) —— Number of samples.

The confidence interval of overall nonconformity rate under confidence level \(1-\alpha\) is:

\[
\left(\hat{p} - u_{1-\alpha/2} \times \sqrt{\hat{p}(1-\hat{p}) / n}, \hat{p} + u_{1-\alpha/2} \times \sqrt{\hat{p}(1-\hat{p}) / n}\right)
\]

When the calculation result in formula (4) is less than 0, 0 shall be taken; when the calculation result in formula (4) is larger than 1, 1 shall be taken.

The point estimate of overall conformity rate is:

\[
1 - \hat{p}
\]

The confidence interval of overall conformity rate under confidence level \(1-\alpha\) is:

\[
\left(1 - \hat{p} - u_{1-\alpha/2} \times \sqrt{\hat{p}(1-\hat{p}) / n}, 1 - \hat{p} + u_{1-\alpha/2} \times \sqrt{\hat{p}(1-\hat{p}) / n}\right)
\]

When the calculation result in formula (6) is less than 0, 0 shall be taken; when the calculation result in formula (6) is larger than 1, 1 shall be taken.

4. Case Application

Taking children's clothes as an example, it is assumed that 2750 sale links are obtained by search on the E-commerce platform, after the sale links are pre-processed and the invalid links such as duplicate links and abnormal price links are eliminated, 2700 valid sale links are obtained; the number of the monitoring total is calculated according to the sum of numbers of products in sale corresponding to all the sale links, and it is assumed that the result is 27000 products, which falls within the range of \((20000 \text{ to } 30000]\).

Step 1: The estimated overall nonconformity rate is 20%, the confidence level is chosen as 95%, and the estimated absolute error is 3%.

Step 2: Calculation of number of samples. By looking up in Table 1, the number of samples is 667.

Step 3: The sampling is carried out in the sampling frame by applying the simple random method.

Step 4: As inspected, the obtained number of nonconformities in the samples is: \(d = 126\).

Step 5: The point estimate of overall nonconformity rate obtained by calculation according to Formula (3) is:

\[
\hat{p} = \frac{126}{667} \times 100\% \approx 18.89055\%
\]
Step 6: The value of point estimate of overall nonconformity rate is rounded to 18.89%;
Step 7: The confidence interval of overall nonconformity rate obtained by calculation according to Formula (4) under the confidence level 95% is: (18.89%-2.97%, 18.89%+2.97%) = (15.92%, 21.86%);
Step 8: Point estimate of overall conformity rate: 100%-18.89%=81.11%;
Step 9: Confidence interval of overall conformity rate: (100%-21.86%, 100%-15.92%) = (78.14%, 84.08%).

5. Conclusion
This paper provides a scientific, normative and operable monitoring sampling method on basis of principles of probability statistics for the E-commerce products with characteristics such as non-warehouse, seller and manufacturer diversity to scientifically master the overall quality level of E-commerce products from macro view or middle view through the estimation of overall quality situation of products sold in E-commerce mode, so as to provide theoretical and technical supports for the work of quality monitoring sampling of E-commerce products in our country.

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