Research on the Mathematical Applications and the Commercial Economy in the Late Qing Dynasty in Tongzhi Sixth Year Distillery Algorithm Example Studies: An Analysis of Economic and Mathematical History Based on Wine Solution Concentration Algorithms and Other Mathematical Models

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Abstract. This paper focuses on Tongzhi Sixth Year Distillery Algorithm Example Studies and conducts an in - depth analysis from the dual perspectives of economic history and the history of mathematics using the literature research method. This document details the calculation methods for distillery operations during the Tongzhi period, including algorithms such as the millet method, the proportional distribution method, the mixed - solution calculation method, and indeterminate equations for wine solution concentration, as well as other commercial mathematical models such as the high - and - low - grade tea method, the principal - and - interest establishment method, and the miscellaneous - use tea method. These algorithms and models reflect the actual needs of distillery operations at that time and the extensive application of mathematics in commercial activities. In terms of economic history, they embody the production technology, management level, cost - profit control strategies of distilleries, and the economic connections between distilleries and other industries, providing important evidence for studying the local economic structure and commercial operation models in the late Qing Dynasty. In terms of the history of mathematics, they demonstrate the development level of commercial mathematics in the late Qing Dynasty, embody the inheritance and innovation of ancient classic mathematics, and reflect the characteristics and evolution process of mathematical applications in that era. This research reveals the business wisdom and mathematical application level of distilleries during the Tongzhi period, providing a unique perspective and valuable materials for research in related fields.

Keywords: Tongzhi Sixth Year Distillery Algorithm Example Studies, solution concentration algorithms, applied mathematics, Shanxi merchants, the late Qing Dynasty.

1. Introduction

According to "Chinese mathematics education system and mathematics education tradition" [1], during the Qing Dynasty, mathematics development presented a unique appearance. At that time, mathematics education occupied a certain position in private schools. Research in "An Overview of Mathematics Education in Private Schools during the Qing Dynasty" [2] shows that private schools, as an important place for private education, undertook the task of imparting basic mathematical knowledge. The teaching content covered arithmetic, geometry, and other aspects. Through reciting formulas and practicing arithmetic problems, students' computing ability and preliminary mathematical thinking were cultivated. This educational model laid the foundation for the spread of mathematical knowledge among the people, enabling mathematics to be widely applied in social and economic activities.

With the prosperity of commerce in the Qing Dynasty, merchants demonstrated unique wisdom in mathematical applications. As an important force in the commercial field at that time, the Shanxi merchants' business activities were inseparable from the support of mathematics. According to relevant research such as "The Rise and Fall of the Shanxi Merchants" [3], "The Shanxi merchants in Beijing in the Qing Dynasty: An analysis based on 136 samples of merchants and their activities" [4], and "The Rise of Shanxi Merchants: Empire, Institutions, and Social Change in Qing China, 1688 - 1850" [5], the Shanxi merchants proficiently used various mathematical methods in trade, financial management, cost accounting, and other aspects. They could accurately calculate the prices and profits of goods, rationally allocate resources, and maximize commercial interests through mathematical means. The close combination of commerce and mathematics not only promoted the rise of the Shanxi merchants but also reflected the crucial role of mathematics in the commercial development of the Qing Dynasty.

Against this historical background, distilleries, as an important part of the local economy, also relied on mathematical algorithms for their operations. During the Tongzhi period, China faced internal and external troubles, and the production, sales, and taxation of distilleries were crucial for the stability of the local economy. Tongzhi Sixth Year Distillery Algorithm Example Studies came into being. This document focuses on the calculation methods in distillery operations and details a variety of algorithms for wine solution concentration and other mathematical models, providing valuable materials for studying the operation management and mathematical applications of distilleries at that time.

The purpose of this research is to deeply analyze Tongzhi Sixth Year Distillery Algorithm Example Studies. Using the literature research method and corroborating it with relevant historical documents such as "Chinese Modern Economic History (1840 - 1894)" and "A Brief History of Ancient Chinese Mathematics" [6, 7], this paper explores its historical value from the dual perspectives of economic history and the history of mathematics. The paper first briefly introduces Tongzhi Sixth Year Distillery Algorithm Example Studies, then analyzes the wine solution concentration algorithms and other mathematical models in detail, and then deeply explores the value of the document in economic history and the history of mathematics. Finally, it draws research conclusions and looks ahead to future research directions.

2. Commercial Mathematics in Tongzhi Sixth Year Distillery Algorithm Example Studies

Tongzhi Sixth Year Distillery Algorithm Example Studies is an important document recording the calculation methods for distillery operations during the Tongzhi period. It elaborates on a variety of algorithms for wine solution concentration, such as the millet method, the proportional distribution method, the mixed - solution calculation method, and indeterminate equations. It also includes mathematical models applied in other commercial fields, such as the high - and - low - grade tea method, the principal - and - interest establishment method, and the miscellaneous - use tea method. These contents reflect the actual needs of distillery operations at that time and the extensive application of mathematics in commercial activities, providing a unique perspective for studying the economic and mathematical development in the late Qing Dynasty.

3. Analysis of Wine Solution Concentration Algorithms: The Mathematical Code for Distillery Operations

3.1. The Millet Method

The millet method is used in the document to solve various wine - concentration blending problems. For example, in Problem 2, given a 46 - proof wine (with a concentration of c_1 =1+0.46 (the naming of variable indices is determined by the sequence in which the variable appears in the document)) of amount a1=32 "zhus" ("zhu" is an ancient Chinese mass unit), and it needs to be blended into a 42 - proof wine (with a concentration of c_2=1+0.42), to find the amount of added water w. First, "take the 32 zhus of 46 - proof wine as the dividend, and multiply it by the 1.46 of the wine's concentration", that is, 32×(1+0.46)=46.72 zhus of flower wine; then "divide it by the 1.42 of the 42-proof wine's concentration", that is, 46.72÷(1+0.42)≈32.9 zhus;finally, "subtract the 32 zhus of the original 46 - proof wine", and the amount of added water w=0.9 zhus. From this, the formula:

$$w = \frac{a_1 c_1}{c_2} - a_1 \tag{1}$$

Is derived. This formula is applicable when the amount of high - concentration flower wine is known and water is added to prepare a low - concentration flower wine.

When the amount of water is known and a higher - concentration flower wine needs to be added to prepare a lower - concentration flower wine, as in Problem 4, the formula can be transformed into

$$a_1 = \frac{wc_2}{c_1 - c_2} \tag{2}$$

Problem 8, although the expression is slightly different, is essentially the same and can be calculated following the above formula. Problem 12 is similar to Problem 4, which is a solution - dilution problem. The formulas

$$w = \frac{a_2(c_1 - c_2)}{c_1}\ ; a_1 = a_2 - \mathrm{w} \tag{3}$$

Can be derived. After correcting the errors in Problem 13 - 2, it also conforms to the millet - method algorithm, and its formula is

$$\mathrm{a}_2 = \frac{\mathrm{a}_3(\mathrm{c}_2 - \mathrm{c}_3)}{\mathrm{c}_1 - \mathrm{c}_2} \tag{4}$$

Although these problems have different variations, the core is to calculate based on proportional relationships, reflecting the application of the millet method in different wine - concentration blending scenarios.

3.2. The Proportional Distribution Method

Take Problem 5 as an example. Given an original 20 - proof wine (with a concentration of c_1=1+0.4), after adding water, it becomes a 20 - proof wine of amount a_2=21 zhus (with a concentration of c_2=1+0.2), and we need to find the amount of added water w. When solving the problem, first, "take the 21 zhus of 20 - proof wine as the dividend, and multiply it by the difference between the 40 - proof wine's concentration (1.4) and the 20 - proof wine's concentration (1.2), which is 0.2", that is, 21×(1.4−1.2)=4.2 zhus;then "divide it by the 1.4 of the 40 - proof wine's concentration", that is, 4.2÷1.4=3 zhus,to get the amount of added water; finally, "subtract the 3 zhus of water from the 21 zhus of wine", and the amount of 40 - proof wine is 18 zhus. Thus, the formula

$$w = a_2 - \frac{a_2(c_1 - c_2)}{c_1} \tag{5}$$

Is summarized.

Problem 7 has an error in the problem statement. After correction, it is of the same type as Problem 5. Problem 10 can also be solved using the formula of Problem 5 and calculated according to the changes of specific physical quantities. The proportional - distribution method analyzes the relationship between the change in wine concentration and the amount of wine to solve practical problems in the wine - blending process. It complements the millet method and enriches the wine - solution concentration algorithm system.

3.3. Mixed - Solution - Proportional Calculation

In Problem 6, given a 46 - proof flower wine (with a concentration of c_1=1+0.46) of amount a_1=442 "jins" ("jin" is an ancient Chinese mass unit), and the amount of added water w=32.5 jins,to find the concentration c_2 of the flower wine after adding water. First, "take the 442 jins of 46 - proof wine as the dividend, and multiply it by the 1.46 of the wine's concentration", that is, 442×(1+0.46)=645.32; then calculate the total mass of the solution 442+32.5=474.5; finally, "divide by this total mass", that is, 645.32÷474.5=1.36, and the resulting concentration is 36 - proof. The formula is

$$c_2 = \frac{a_1 c_1}{a_1 + w} \tag{6}$$

Problem 11 is about mixing two flower wines with different concentrations to find the resulting concentration. It is essentially the same as Problem 6, both calculating the proportion of the total mass of alcohol in the solution to the total mass of the solution. Following the steps of Problem 6, the formula

$$c_2 = \frac{a_1c_1+a_2c_2}{a_1+a_2} \tag{7}$$

Can be summarized. The first part of Problem 13 is similar to Problem 6. Although there are errors in the problem statement and solution, the correct answer can be obtained by using the formula, further verifying the correctness and practicality of this algorithm.

3.4. Indeterminate Equations

In Problem 9, the original problem should be an indeterminate - equation problem. The author presupposes that the original flower - wine concentration is 46 - proof, that is, given the original flower - wine concentration in the tank a1=1+0.46, 120 jins of 20 - proof flower wine (with a concentration of c_3=1+0.2) is added, and finally, a 40 - proof flower wine (with a concentration of c2=1+0.4) is obtained. To find the mass of the original flower wine in the tank. When solving the problem, first, "take the 120 jins of 20 - proof wine as the dividend, and multiply it by the difference between the 40 - proof wine's concentration (1.4) and the 20 - proof wine's concentration (1.2)", that is, 120×(1.4−1.2)=24; then "take this result as the dividend, and divide it by the difference between the 46 - proof wine's concentration (1.46) and the 40 - proof wine's concentration (1.4)", that is, 24÷(1.46−1.4)=400 jins. This problem, similar to other problems, has issues such as unit conversion and imprecise expressions, but it still shows the exploration and solution ideas for complex wine - concentration problems at that time.

4. Exploration of Other Mathematical Models: Mathematical Wisdom in the Commercial Field

In addition to the wine - solution concentration algorithms, Tongzhi Sixth Year Distillery Algorithm Example Studies also records a large number of other mathematical cases and models. These models are widely applied in various fields of commercial activities, reflecting the diversity and practicality of commercial mathematics at that time. The high - and - low - grade tea method is used to solve the quantity - distribution problem in tea trading. The principal - and - interest establishment method is used for principal - and - interest calculations in the financial field. The miscellaneous - use tea method is used for the purchase and distribution of goods with multiple prices. In addition, there are calculation methods for problems such as buying pork and tofu and silver - money conversion. These mathematical models complement the algorithms in distillery operations and jointly form the rich system of commercial mathematics at that time.

4.1. The High - and - Low - Grade Tea Method

Given the total amount of money p=182 "diaos" ("Diao" is an ancient Chinese mass unit. One "diao" approximates one tael. Specifically, in the sixth year of Tongzhi reign, one "diao" is smaller than one tael because of the devaluation of the silver), the price per jins of high - grade tea p_1=4.8 diaos, the price per jin of low - grade tea p_2=3.2 diaos, and the total mass of the two kinds of tea m=50 jins,to find the mass of high - grade tea m_1 and the mass of low - grade tea m_2. First, "take the total 50 jins of the two kinds of tea as the dividend, and multiply it by the 4800 - wen price of high - grade tea", that is, 50×4.8=240 diaos;"subtract the 182 diaos of money from it", getting 240-182=58 diaos;"subtract the 3200 - wen price of low - grade tea from the 4800 - wen price of high - grade tea, and the difference is 1600 wen = 1.6 diaos,which is used as the divisor"; finally, "divide to get the mass of low - grade tea, which is 36.25 jins", 58÷1.6=36.25 jins. Then, the mass of high - grade tea m_1=50−36.25=13.75 jins. The formulas:

$$m_2 = \frac{mp_1 - p}{p_1 - p_2};\ m_1 = m - m_2 \tag{8}$$

Are derived. This model is used to solve the quantity - distribution problem in tea trading, reflecting the application of proportional calculations in commercial transactions.

4.2. The Principal - and - Interest Establishment Method

Given the total principal and interest silver p=445 taels, and the interest rate per tael of silver p_3 (two - and - a - half cents, with a total of 1.25 taels for principal and interest), to find the principal silver p_1 and the interest silver p_2. First, "take the 445 taels of total principal and interest silver as the dividend, and divide it by the 1.25 taels of principal and interest per tael of silver", that is, 445÷1.25=356 taels, to get the principal silver; "subtract the 356 taels of principal silver from the 445 taels of total principal and interest silver", and the interest silver p_2=445−356=89 taels. The formulas

$$p_1 = \frac{p}{1+p_3}; p_2 = p - p_1 \tag{9}$$

Are derived, which are used to solve the principal - and - interest calculation problem in the financial field and reflect the capital - accounting method in commercial activities at that time.

4.3. The Miscellaneous - Use Tea Method

Given 18 diaos of cash, and it is necessary to buy 6 jins of four - color tea. The prices per jin of the four kinds of tea are 4800 wen, 3200 wen, 2400 wen, and 1600 wen respectively. Through specific calculation steps, it is finally obtained that each kind of tea is 1.5 jins. This method is also based on proportional relationships and solves the purchase - distribution problem of goods with multiple prices, demonstrating the application of commercial mathematics in complex trading scenarios.

4.4. Other Miscellaneous Examples

The document also records problems such as buying pork and tofu and silver - money conversion. For example, in the problem of buying pork and tofu, given 9 cents of fine - silver and the prices and total mass of pork and tofu, the masses of pork and tofu are obtained through specific calculation methods. Although there are errors in the silver - money conversion problem, it still reflects the actual situation of currency conversion in commercial activities at that time, embodying the wide application of commercial mathematics.

5. Literature Value and Significance: Mathematical Memories in the Long History Scroll

5.1. Economic - History Value

In - depth research on Tongzhi Sixth Year Distillery Algorithm Example Studies is of great significance for economic - history research. From the perspective of wine - solution concentration algorithms, the precise control of wine quality reflects the relatively high production technology and management level of distilleries at that time. Through these algorithms, distilleries could accurately blend wines with different concentrations according to market demands, meeting the diverse needs of consumers. This not only reflects the fine - grained operation in the production process of distilleries but also indicates their effective control over costs and profits.

Analyzing from other mathematical models, the application of methods such as the high - and - low - grade tea method and the principal - and - interest establishment method in commercial transactions demonstrates the calculation and distribution methods of commodity prices and quantities at that time. Through these models, we can infer the cost - control strategies of distilleries and related commercial activities. For example, when purchasing raw materials, how to make rational choices based on prices and quality; in the sales process, how to set prices to maximize profits. This information provides crucial evidence for studying the local economic structure and commercial operation models in the late Qing Dynasty.

In addition, the application of mathematical algorithms and models in the document reflects the importance of distilleries in economic activities and their close economic connections with other industries. The production of distilleries requires raw materials such as grains and containers, and their sales involve multiple links such as transportation and retail, which are interrelated with industries such as agriculture, handicrafts, and commerce. Studying these algorithms and models helps to deeply explore the recovery and development of the late - Qing economy in a difficult situation, as well as the mutual influence and interaction mechanisms among various industries.

5.2. The Value in the History of Mathematics

This document also has undeniable value in the study of the history of mathematics. The wine - solution concentration algorithms and other mathematical models in it demonstrate the development level of commercial mathematics in the late Qing Dynasty. Algorithms such as the millet method and the proportional distribution method have an inheritance relationship with those in ancient classic mathematical works, and at the same time, they have been innovated in combination with the actual operation of distilleries. For example, the millet method in "The Nine Chapters on the Mathematical Art" takes the "current - having method" as the core and constructs the basis of proportional algorithms [8]. The millet method in Tongzhi Sixth Year Distillery Algorithm Example Studies, when solving wine - concentration blending problems, expands and applies the traditional millet method, making it more suitable for the actual operation scenarios of distilleries.

Although there are some inaccuracies in the use of units and calculation methods in the document, they also reflect the characteristics of mathematical applications in that era. These characteristics reflect the evolution process of mathematics in practical applications and provide physical evidence for studying the development context of ancient Chinese mathematics. Through the study of this document, we can clearly observe the changes in the application of mathematics in different historical periods and industries, as well as the continuous enrichment and improvement of mathematical knowledge in practice. This not only enriches the research content of the history of mathematics but also provides important clues for a deeper understanding of the mutual relationship between mathematics and social - economic development.

6. Conclusion

The wine - solution concentration algorithms and other mathematical models recorded in Tongzhi Sixth Year Distillery Algorithm Example Studies are important manifestations of commercial mathematics in the late Qing Dynasty. These algorithms and models played a crucial role in distillery operations and other commercial activities, reflecting the close combination of commerce and mathematics at that time. Through the study of this document, we not only reveal the business wisdom and mathematical application level of distilleries during the Tongzhi period but also provide a unique perspective and valuable materials for economic - history and mathematics - history research.

Future research can further explore the connections between this document and other contemporary commercial documents, and deeply explore the mechanism of the role of commercial mathematics in the social - economic development of the late Qing Dynasty. For example, study the application differences of these mathematical algorithms and models in different regions and industries, as well as their specific promoting effects on commercial development. At the same time, we can compare the mathematical methods in different documents, analyze their similarities and differences, and provide more abundant research results for a comprehensive understanding of the history of the late Qing Dynasty.

References

[1] Qin D. Chinese mathematics education system and mathematics education tradition. The 21st century mathematics education in China, 2018: 27 - 52.

[2] Li X.Y., Li W.J. An Overview of Mathematics Education in Private Schools during the Qing Dynasty. Lantai World, 2015(10): 91 - 92.

[3] Zhang Z.M., Zhang S. The Rise and Fall of the Shanxi Merchants. Shanxi: Shanxi Economic Publishing House, 2010.

[4] Songyi G. The Shanxi merchants in Beijing in the Qing Dynasty: An analysis based on 136 samples of merchants and their activities. Frontiers of History in China, 2009, 4: 165 - 182.

[5] Qiao Z. The rise of Shanxi merchants: empire, institutions, and social change in Qing China, 1688 - 1850. Stanford University, 2017.

[6] Yan Z.P. Chinese Modern Economic History (1840 - 1894). Beijing: People's Publishing House, 2001.

[7] Li Y., Du S.R. A Brief History of Ancient Chinese Mathematics. Beijing: Zhonghua Book Company, 1964.

[8] Zhang C., Geng S.C. The Nine Chapters on the Mathematical Art. Jiangsu: Jiangsu People's Publishing House, 2011.