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Original Paper

Fuel Budget for Tobacco Logistics Distribution Based on MA -Least Squares Method

Xuefeng Peng[1], Bin Chen[1*], & Shi He[2]

[1] China National Tobacco Corporation Sichuan Branch, Chengdu, 610041, China

[1] China National Tobacco Corporation Sichuan Branch, Chengdu, 610041,China

[2] Sichuan Tobacco Company Liangshan Prefecture Company, Liangshan, 615000, China

[*] Corresponding author

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Abstract

Implementing the dual carbon development strategy is a responsibility and task that state-owned enterprises must undertake. Research has found effective financial budgets, which can drive innovative development and promote green development. This article takes the commercial logistics distribution of cigarettes as the research object and proposes a distribution budget model based on quadratic moving average combined with least squares method. By collecting historical data, a quadratic moving average distribution mileage prediction model is established. Based on the distribution mileage, the fuel consumption is calculated using the least squares method, and then combined with the average fuel price, the fuel cost is scientifically and rigorously predicted to make accurate and effective budgets.

Keywords

tobacco logistics, Moving average, Least squares method, Tobacco delivery

1. Introduction

The Guiding Opinions on Accelerating the Construction of a World Class Financial Management System for Central Enterprises issued by the State owned Assets Supervision and Administration Commission of the State Council clearly states that digital transformation and deep integration of financial management should be taken as the starting point to accelerate the construction of a world-class financial system. Effective financial management is not only a strategic measure for enterprises to reduce costs, increase efficiency, and empower development, but also a necessary path for the country to achieve economic transformation and upgrading, improve the efficiency of the national economy, and promote the sustainable development of China's socialist economic system with distinctive characteristics.

Making a good budget is of great help to the country and enterprises. It has significant benefits in optimizing resource allocation, improving resource utilization efficiency, and supporting innovation. Yu and Gu (2023) proposed cloud native lean budgeting techniques (Yu & Gu, 2023); Xiao, Tao, and Wang (2024) Budget performance management can strengthen financial revenue and expenditure management (Xiao, Tao, & Wang, 2024); From the perspectives of debt and capital, Wang and Hou (2024) proposed requirements for budget management (Wang & Hou, 2024), and Tian et al. (2024) pointed out that "data+algorithm+computing power" is the underlying architecture of business finance integration (Tian & Gao, 2024). These studies all demonstrate the value of budgeting.

In 2022, the logistics cost of cigarettes for commercial enterprises nationwide was 119 6.6 billion yuan, in terms of cost analysis, the proportion of delivery costs to total logistics costs is the highest at 45.84%, how to improve the accuracy of fuel consumption budget in the delivery process is an important issue for logistics. On the one hand, optimizing the use of fuel, and on the other hand, actively responding to the country's dual carbon strategy goals and fulfilling the responsibilities of state-owned enterprises.

Guan, Xu and Yu (2022) introduced the grey box model method to establish a ship fuel consumption model (Guan, Xu & Yu, 2022); Zou, Li, et al. (2023) introduced the grey box model method to establish a ship fuel consumption model (Zou, Li, Deng etc., 2023); Shi et al. (2023) proposed the XGBoost MIIWOA-LSTM prediction model for predicting fuel consumption (Shi, Hu, Gong, etc., 2024); Zhong, Zhang, and Gu (2023) conducted research on multi-objective optimization scheduling of tugboats based on time and fuel consumption (Zhong, Zhang & Gu, 2023); Huang et al. (2022) found that improved ECMS with equivalent factor optimization has better fuel economy (Huang, Xu, & Bian, etc., 2023); Zhang et al. (2023) established an integer nonlinear programming model for synergistic optimization of truck speed and signal timing to predict fuel consumption (Zhang, Gu & Sun, 2023); Yao et al. (2023) conducted research on data-driven ship fuel consumption prediction models using Extreme Learning Machine (ELM) algorithms (Yao, Wang, Zhang, etc, 2023); Pan, Guo, and Jin (2023) proposed a fuzzy adaptive energy management strategy based on particle swarm optimization to minimize equivalent fuel consumption (Pan, Guo, & Jin, 2023); Han et al. (2023) proposed a gradient boosting joint personalized federated learning method based on categorical features for predicting fuel consumption (Han, Sun, Liu etc., n.d.); Tan et al. (2020) established a mathematical model for fuel consumption of pump trucks (Tan, Li, Tong, etc., 2023).

Through existing research on fuel consumption prediction, it has been found that accurate prediction of fuel consumption is necessary to make accurate fuel consumption cost predictions, rather than simply making budgets based on historical data. Models are an important component of achieving fast and accurate budgeting, and it is also based on the development of business finance integration to make more efficient fuel consumption budgets.

2. Design of Fuel Consumption Budget Model

2.1 Second Moving Average Model

The moving average method is a time series prediction method that uses segmented and point by point averaging to process time series data, identify the historical changes of the predicted object, and establish a prediction model based on this. The specific method is to divide the known data points into several segments, and then move them point by point in the order of the data points, and calculate their average value point by point, in order to obtain a new set of data with a more obvious trend. Due to its time lag, it is generally not used for direct prediction. Instead, a moving average prediction model is established based on the average of one and two movements before making predictions.

(1) One time moving average:

$$M_t^1 = \frac{X_t + X_{t-1} + \dots + X_{t-n+1}}{n}$$ ……………………………..(formula1)

M_t^1—The first moving average of the t-th period;

X_t—Actual value of the t-th period;

n—One moving average period.

(2) Secondary moving average:

$$M_t^2 = \frac{M_t^1 + M_{t-1}^1 + \dots + M_{t-n+1}^1}{n}$$ …………………………..…..(formula2)

M_t^2—The second moving average of the t-th period;

M_t^1—The moving average of the t-th period;

n—Second moving average period.

The number of periods for a first moving average and a second moving average should be the same, and there should be no phenomenon where the number of periods for a first moving average is different from that for a second moving average.

(2) Prediction model

$$X_{t+T} = a_t + b_t T$$ ……………………………………..(formula3)

X_{t+T} —The predicted value for the t+T period;

a_t —Constant values of predictive models;

b_t —Predict the time period coefficient value of the model.

$$a_t = 2M_t^1 - M_t^2$$ …………………………………………..(formula4)

$$b_t = \frac{2}{n-1} * (M_t^1 - M_t^2)$$ …………………………………..(formula5)

Among them, n has the same meaning as the first and second moving averages, representing the number of periods of movement.

2.2 Least Square Method

The least squares method (also known as the minimum mean square method) is used to find the best function match for data by minimizing the sum of squared errors. By using the least squares method, unknown data can be easily obtained, and the minimum value of the sum of squared deviations of the model can be calculated.

$$S(\hat{a}, \hat{b}) = \sum_{i=1}^{n} e_i^2 = \sum_{i=1}^{n} (Y_i - \hat{a} - \hat{b}X_i)^2$$ ……………………..(formula5)

Firstly, calculate the partial derivatives of $S(\hat{a}, \hat{b})$ with respect to $\hat{a}, \hat{b}$, and let=0 to obtain the system of equations:

$$\frac{\partial S(\hat{a},\hat{b})}{\partial \hat{a}} = -2\sum_{i=1}^{n} (Y_i - \hat{a} - \hat{b}X_i) = 0$$ ………………………..(formula6)

$$\begin{cases} \frac{\partial S(\hat{a},\hat{b})}{\partial \hat{a}} = -2\sum_{i=1}^{n} (Y_i - \hat{a} - \hat{b}X_i) = 0 \\ \frac{\partial S(\hat{a},\hat{b})}{\partial \hat{b}} = -2\sum_{i=1}^{n} (Y_i - \hat{a} - \hat{b}X_i)X_i = 0 \end{cases}$$ …………………..(formula7)

Obtain the normal system of equations formula8 from formula7

$$\begin{cases} \sum_{i=1}^{n} Y_i = n\hat{a} + \hat{b}\sum_{i=1}^{n} X_i \\ \sum_{i=1}^{n} X_i Y_i = \hat{a}\sum_{i=1}^{n} X_i + \hat{b}\sum_{i=1}^{n} X_i^2 \end{cases}$$ ……………………..…..(formula8)

Obtain $\hat{a}, \hat{b}$ from formula8 and solve formula9

$$\begin{cases} \hat{b} = \frac{\sum X_i Y_i - n\bar{X}\bar{Y}}{\sum X_i^2 - n(\bar{X})^2} \\ \hat{a} = \bar{Y} - b\bar{X} \end{cases}$$ ……………………………………..…..(formula9)

Finally, the regression function $Y = \hat{a} + \hat{b}X$, Through the regression coefficient R value and collinearity test, if R ≥ 0.8, it indicates a strong correlation between the independent variable and the dependent variable, and the change in the independent variable can explain the change in the dependent variable well. If the collinearity value is ≥ 5, it indicates that the independent variables are not independent and cannot explain the changes in the dependent variable well, and the independent variables need to be corrected.

2.3 Fuel Consumption Budget Model

$$C = p * Y = p * (\hat{a} + \hat{b} * X_{t+T})$$ ………………………..…..(formula10)

formula 中：

C —Representing fuel consumption costs;

p —Indicate the unit price of oil;

Y —Oil consumption;

X_{t+T} —Delivery mileage.

3. Application of Fuel Consumption Budget Model

By collecting fuel consumption data from Chengdu Tobacco Logistics Center from 2016 to 2020, a time series data is formed.

3.1 Delivery Mileage Prediction Based on Quadratic Moving Average

Using data from 5 years and 60 months from 2016 to 2020, the study found that when selecting the number of moving average periods, n=5 resulted in more accurate predictions.

Firstly, perform a smoothing calculation and input the delivery kilometer data into a moving average model to obtain the calculation results in column 3 of Table 1.

Step 2: Perform a second moving average calculation and substitute it into the second moving average model to obtain the calculation results in column 4 of Table 1.

Step three, calculate the values of a_t and b_t, as shown in columns 5 and 6 of Table 1.

Table 1. Calculation Results of Second Moving Average

Date	Total mileage of delivery route (kilometers)	One time moving average (kilometers)	Secondary moving average (kilometers)	a_t	b_t
2016/1	296281				
2016/2	191232				
2016/3	233867				
2016/4	207069				
2016/5	210931				
2016/6	231441				
2016/7	218760	227083.00			
2016/8	240481	219111.57			
2016/9	239552	226014.43		497231.74	113007.21
2016/10	181665	218557.00		480825.40	109278.50
2016/11	235146	222568.00		489649.60	111284.00
2016/12	220659	223957.71		492706.97	111978.86
2017/1	358024	242041.00	225618.96	306871.24	8211.02
2017/2	187252	237539.86	227112.80	295474.89	5213.53
2017/3	238682	237282.86	229708.69	292313.59	3787.08
2017/4	211356	233254.86	230743.04	282417.64	1255.91
2017/5	204224	236477.57	233303.12	286947.53	1587.22
2017/6	224496	234956.14	235072.86	281830.66	-58.36
2017/7	218199	234604.71	236593.86	279536.51	-994.57
2017/8	234827	217005.14	233017.31	244394.01	-8006.08
2017/9	220513	221756.71	230762.57	257102.20	-4502.93
2017/10	183836	213921.57	227425.24	243202.21	-6751.84
2017/11	226229	216046.29	224966.88	250334.95	-4460.30
2017/12	184438	213219.71	221644.33	247439.04	-4212.31

2018/1	339657	229671.29	220889.35	284387.48	4390.97
2018/2	121803	215900.43	218217.31	256763.64	-1158.44
2018/3	216862	213334.00	217692.86	251641.94	-2179.43
2018/4	213978	212400.43	216356.24	250924.70	-1977.91
2018/5	219399	217480.86	216864.71	261593.17	308.07
2018/6	188917	212150.57	216308.18	250423.07	-2078.81
2018/7	224219	217833.57	216967.31	262266.55	433.13
2018/8	239675	203550.43	213235.76	234575.19	-4842.66
2018/9	217558	217229.71	213425.65	264479.72	1902.03
2018/10	182040	212255.14	213271.53	253689.78	-508.19
2018/11	216344	212593.14	213299.06	254405.85	-352.96
2018/12	147392	202306.43	211131.29	233942.86	-4412.43
2019/1	321339	221223.86	212427.47	274265.02	4398.19
2019/2	195290	217091.14	212321.41	265279.11	2384.87
2019/3	255757	219388.57	214584.00	268070.86	2402.29
2019/4	225980	220591.71	215064.29	270237.49	2763.71
2019/5	202402	223500.57	216670.78	275030.48	3414.90
2019/6	210612	222681.71	218112.00	271787.77	2284.86
2019/7	240559	235991.29	222924.12	296256.71	6533.58
2019/8	224964	222223.43	223066.92	265824.62	-421.74
2019/9	239876	228592.86	224710.02	278194.27	1941.42
2019/10	191371	219394.86	224710.92	257957.77	-2658.03
2019/11	211298	217297.43	224240.31	253814.04	-3471.44
2019/12	206695	217910.71	223441.76	255961.82	-2765.52
2020/1	368447	240458.57	225981.31	303027.55	7238.63
2020/2	167811	230066.00	225134.84	281010.36	2465.58
2020/3	233336	231262.00	226426.06	282350.34	2417.97
2020/4	234028	230426.57	226688.02	280250.44	1869.28
2020/5	208617	232890.29	228615.94	283742.69	2137.17
2020/6	231839	235824.71	231262.69	287551.68	2281.01
2020/7	243927	241143.57	234581.67	295934.18	3280.95
2020/8	228273	221118.71	231818.84	254642.33	-5350.06
2020/9	240503	231503.29	232024.16	277283.07	-260.44
2020/10	170874	222580.14	230783.90	258892.42	-4101.88
2020/11	188807	216120.00	228740.10	246723.90	-6310.05
2020/12	160834	209293.86	225369.18	235077.30	-8037.66

The delivery mileage transportation model： $X_{t+T} = 235077.30 - 8037.66T$

3.2 Fuel Consumption Prediction Based on Least Squares Method

The study found a high correlation between fuel consumption and delivery mileage, so fuel consumption can be used as the dependent variable and delivery mileage as the independent variable, and the least squares method can be used to find the linear relationship between them.

Through analysis, the regression coefficient R=0.95 indicates a strong positive correlation between delivery mileage and fuel consumption, as shown in Table 2.

Table 2. Regression Coefficient Table

model	R	R-squared	Adjusted R-squared	Error in standard estimation
1	.950[a]	.902	.901	2454.80300
a. Predictive variable: (constant), total mileage of delivery route (kilometers)				

Through the analysis of variance in Table 3, the total sum of squares is 3574972740, and the sum of squares of regression is 3225461389, further proving the reliability of the regression coefficients. The independent variable can effectively explain the changes in the dependent variable.

Table 3. ANOVA[a]

Model		Sum of squares	Freedom	Mean square	F	Significance
1	Regression	3225461389.000	1	3225461389.000	535.252	.000[b]
	Residual	349511351.100	58	6026057.777		
	Total	3574972740.000	59			
a. Dependent variable: Total fuel consumption (liters)						
b. Predictive variable: (constant), total mileage of delivery route (kilometers)						

According to Table 4, reviewing the model: total fuel consumption=-972.618+0.169 * total mileage of the delivery route

Table 4. Regression Model Coefficients[a]

Model	Non standardized coefficient	standardized coefficient	t	Significance	Collinearity statistics

		B	error	Beta			Tolerance	VIF
1	(Constant)	-972.618	1652.696		-.589	.558		
	Total mileage of delivery route (kilometers)	.169	.007	.950	23.136	.000	1.000	1.000

a. Dependent variable: Total fuel consumption (liters)

3.3 Fuel Consumption Budget

When calculating costs, oil price is an essential independent variable. Oil price can be calculated using the average oil price of the previous year, while logistics center delivery vehicles generally use 92 octane gasoline. Therefore, when calculating, the average price of 92 octane gasoline in the previous year is used. If the predicted delivery mileage in May 2021 is 194888.99 kilometers, the fuel consumption is 31963.62 liters. The average price of 92 octane gasoline in 2020 is 5.56 yuan/liter, so the fuel consumption budget for May 2021 is C=177717.73 yuan.

4. Suggestions for the Development of Fuel Consumption Budget

At present, there are still many problems in the budget for fuel consumption expenses, and the underlying reason is the lack of the concept of business finance integration and the weakening of cost control awareness. The main function of tobacco commercial logistics is to provide logistics services without directly generating economic profits. The operation of this logistics system does not directly involve profitable cash flow, and the corresponding business budget and cost control concepts are insufficient. The concept of business finance integration is also lacking, and the degree of data utilization is not high, only staying at the level of financial statements.

The circuitous distribution routes may also lead to inefficient vehicle scheduling, especially in recent years with the rapid expansion of urban areas and the radiating distribution of new retail customers, which will inevitably result in repeated vehicle travel and resource idle.

4.1 Building a Business Finance Integration Platform

Business dataization. Establish a common database between business and finance departments, starting from standardizing business processing procedures, setting standardized cost quotas, working hour quotas, efficiency quotas, and standard fuel consumption quotas for the distribution process, standardizing data collection and processing, data exchange and storage in the distribution process, and comprehensively realizing financial informatization and business informatization.

Data sharing. By utilizing digital technology, we aim to build a big data platform that integrates multi-dimensional and multi-level sharing systems between finance and business, opens up channels for collecting information and data flows, achieves data structuring, improves resource allocation efficiency, and provides platform support for data sharing and integration.

4.2 Establishing the Concept of Integrating Business and Finance

Based on the value chain, establish the concept of business finance integration and innovate the formula for business finance integration. Taking financial management as the core of management and business as the foundation, integrating financial indicators, business indicators, and benchmark indicators for development, promoting the integration of industry and finance learning for all employees, deeply practicing the concept of industry and finance integration, and achieving high-quality development of industry and finance integration.

4.3 Developing New Energy Distribution through a Combination of Leasing and Purchasing

By combining vehicle procurement and long-term leasing models, actively exploring the leasing and use of new energy vehicles, replacing all urban routes with new energy vehicles in good road conditions, reducing operating costs, lowering safety hazards and asset management risks, and transferring the cost of vacant backup vehicles. At the same time, by conducting weighted analysis on cigarette loading and unloading, delivery mileage, delivery households, delivery quantities, and other data, optimizing delivery routes, reasonably optimizing delivery mileage, and reducing delivery fuel consumption.

The economic value created by enterprises should be evaluated from both absolute and relative perspectives. The good or bad operation of an enterprise is not only reflected in the reduction of costs, but also in the improvement of efficiency, time, quality, and other aspects. Therefore, we should not only focus on the explicit issues of data processing, but also pay attention to the implicit factors hidden behind the data.

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