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Research on the Dynamic Analysis Application of Calculus in Product Pricing Strategies an Empirical Study Based on Yiwu Small Commodities Market

Fangyan Ma [1,*] and Ju Jiang [2]

[1] Hainan Vocational University of Science and Technology, Hainan, 571126, China
[2] Yiwu Anku Daily Necessities Co., Ltd, Zhejiang, 322002, China
* Correspondence: Fangyan Ma, Hainan Vocational University of Science and Technology, Hainan, 571126, China

Abstract: To address the dilemma that traditional static pricing fails to adapt to the dynamic market changes, this study constructs a product dynamic pricing analysis system based on calculus theory. By employing core tools including derivatives, differential equations, and integrals, it quantifies the correlation mechanism between dynamic variables (such as cost fluctuations, demand elasticity, and competitive dynamics) and product pricing. Taking 18 typical products across 6 categories in the Yiwu Small Commodities Market as the research objects, combined with the market's historical transaction data from 2021 to 2024, this study establishes three models: a marginal cost pricing model, a dynamic demand elasticity adjustment model, and an integral-based product lifecycle pricing model. The model accuracy is verified using three metrics: Mean Absolute Error (MAE), Root Mean Square Error (RMSE), and Mean Absolute Percentage Error (MAPE). The results indicate that the prediction accuracy of the calculus-based dynamic pricing model is significantly superior to that of the traditional static pricing model, with an average MAPE of only 6.8%, a reduction of 13.2 percentage points compared with static pricing. After the application of this model, the average gross profit margin of the 18 products increased by 8.3%, among which products with high demand elasticity (e.g., disposable toothbrushes and non-woven shopping bags) achieved a profit growth rate of over 18%. This study confirms that calculus provides a precise quantitative analysis tool for dynamic pricing, and its core value lies in transforming pricing from an "experience-based judgment" to a "data-driven" approach. It offers theoretical support and practical paradigms for Yiwu small commodity enterprises to formulate flexible and efficient pricing strategies.

Keywords: calculus; dynamic pricing; demand elasticity; marginal cost; Yiwu small commodities; error analysis

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1. Introduction

1.1. Research Background and Problem Statement

Driven by the dual engines of the digital economy and consumption upgrading, the small commodities market is increasingly characterized by volatile demand, fluctuating costs, and intense competition. As the world's largest small commodities distribution hub, Yiwu achieved a total market turnover of RMB 126.88 billion in 2023. However, surveys conducted among merchants in Yiwu Small Commodity City indicate that approximately 62% of merchants still rely on a static "cost-plus" pricing strategy. Among them, 45% face the persistent dilemma of declining sales due to overpricing or profit erosion caused by underpricing. Traditional pricing practices are largely dependent on merchants' experiential judgment, which makes it difficult to accurately capture the influence of dynamic factors such as fluctuations in raw material prices-where bulk commodities such as plastics and alloys may vary by 20%-30% within half a year-and seasonal demand changes, as exemplified by the fact that sales volumes of festival-related products during peak seasons can be five to eight times higher than those in off-seasons.

As a core determinant of enterprise profitability, product pricing essentially represents a comprehensive balancing process among multiple dimensions, including costs, demand, and competition. The dynamic nature and strong interdependence of these variables urgently call for precise quantitative analysis tools. As a fundamental branch of advanced mathematics, calculus possesses inherent advantages in describing variable change patterns and solving extremum and optimization problems, thereby offering a feasible analytical framework for addressing dynamic pricing challenges. Nevertheless, existing studies on the application of calculus to small commodity pricing largely remain confined to single-dimensional and static analytical perspectives. They lack multi-variable dynamic coupling analyses that are closely aligned with the operational characteristics of the Yiwu market, and thus have not yet yielded scalable and practically applicable solutions. Against this backdrop, the construction of a calculus-based dynamic pricing system tailored to Yiwu small commodities, aimed at resolving the contradiction between variable dynamism and pricing precision, carries significant practical relevance and theoretical value.

1.2. Literature Review and Research Significance

Scholars both domestically and internationally have long recognized the application value of mathematical tools in pricing research. In international studies, early oligopoly pricing theory introduced derivative-based methods to solve profit-maximization equilibrium problems, thereby laying the theoretical foundation for marginal pricing analysis [1]. Subsequent price competition models further expanded the quantitative analysis framework for competitive pricing. However, these classical models are largely built on assumptions of static variables and equilibrium states, and thus tend to overlook the dynamic evolution of real markets. With the advancement of dynamic pricing theory in recent years, differential equations have been introduced into revenue management pricing research, providing a more refined analytical perspective. Nevertheless, most of these studies focus on service-oriented industries such as aviation and hospitality, whose operational characteristics differ substantially from those of small commodities, particularly in terms of low unit costs and large transaction volumes [2]. As a result, their applicability to small commodity markets remains limited.

In domestic research, existing studies have explored pricing adjustment strategies based on factors such as demand elasticity and mathematical modeling. However, many of these works lack concrete quantitative calculation methods specifically designed for small commodities, or fail to incorporate cost fluctuations, which constitute a core influencing factor in small commodity pricing. Research related to Yiwu small commodities has primarily concentrated on circulation mechanisms, market organization, and brand development, while systematic applications of quantitative analytical tools-especially calculus-based methods-in pricing decisions remain scarce [3]. Overall, current studies exhibit several prominent limitations, including a focus on single-dimensional variables, insufficient alignment with real market scenarios, and weak operational feasibility. These shortcomings prevent the dynamic analytical advantages of calculus from being fully utilized in the context of small commodity pricing, thereby underscoring the necessity and significance of further research in this area.

1.3. Research Methods and Technical Route

This study adopts a structured research path of "theoretical construction-model design-empirical testing-error analysis." First, the literature research method is employed to systematically review and synthesize the core achievements in calculus theory, dynamic pricing theory, and the pricing characteristics of small commodities, with the aim of clarifying the mechanisms of interaction and correlation among key variables. Second, the model construction method is applied to develop three categories of dynamic pricing models-namely marginal cost-based models, demand elasticity-based models, and product life cycle-based models-by respectively utilizing derivatives, differential equations, and integral analysis tools. Third, the empirical analysis method is conducted by selecting 18 representative products from six categories in the Yiwu Small Commodities Market as research samples [4]. Historical transaction data, including cost, sales volume, and price, from 2021 to 2023 are collected for model parameter estimation, while data from January to June 2024 are used for out-of-sample validation of the proposed models. Finally, the error analysis method is adopted by applying three evaluation indicators-MAE, RMSE, and MAPE-to compare the predictive accuracy of the proposed dynamic pricing models with that of traditional static pricing models, thereby verifying the effectiveness and practical applicability of the models [5].

2. Theoretical Basis and Core Tools of Calculus in Dynamic Pricing of Small Commodities

2.1. Core Theoretical Support

The core goal of dynamic pricing for small commodities is to maximize merchant revenue under the premise of dynamic changes in variables such as costs and demand, which is highly consistent with the core idea of calculus-"solving optimization problems". Its theoretical logic is based on three points: first, the marginal equilibrium principle, i.e., when marginal revenue (MR) equals marginal cost (MC), the enterprise achieves profit maximization. This equilibrium point can be obtained by solving the extremum through derivatives, which is suitable for the "small profits but quick turnover" profit model of small commodities; second, the dynamic evolution principle, the small commodity pricing system exhibits continuous evolution characteristics with time changes (e.g., seasons and festivals), and differential equations can accurately describe this process (e.g., the periodic fluctuation of demand for festival supplies); third, the cumulative revenue principle, integrals can realize the cumulative calculation of revenue throughout the product lifecycle, providing a basis for the pricing strategy of "boosting sales in peak seasons and clearing inventory in off-seasons" for small commodities [6].

2.2. Core Calculus Tools and Application Scenarios

2.2.1. Derivatives and Marginal Analysis

Derivatives describe the instantaneous rate of change of functions, and are mainly used in small commodity pricing for calculating marginal cost and marginal revenue and solving extremum values. Let the product price be P, sales volume Q (where Q is a function of P, i.e., $Q = f(P)$), and total cost be $C(Q)$. Then total revenue $R = P \times Q = P \times f(P)$, marginal revenue $MR = \frac{dR}{dP}$, and marginal cost $MC = \frac{dC}{dQ} \times \frac{dQ}{dP}$. Setting $MR = MC$, the optimal pricing P^* can be obtained by derivation. This tool is applicable to small commodities with frequent raw material price fluctuations, such as plastic daily necessities and alloy jewelry.

2.2.2. Differential Equations and Dynamic Evolution

When multiple variables in the pricing system change with time t and interact with each other, differential equations can construct a dynamic correlation model between variables. Assuming that price $P(t)$, demand $Q(t)$, and cost $C(t)$ are all functions of time, combined with the seasonal demand characteristics of Yiwu small commodities, the differential equation $\frac{dP}{dt}=k[Q(t)-C'(t)]$ is established (where k is the adjustment coefficient reflecting the speed of merchants' pricing adjustment). The evolution path of price over time $P(t)$ can be obtained by solving the differential equation. This tool is suitable for products with significant demand fluctuations such as festival supplies and seasonal toys.

2.2.3. Integrals and Product Lifecycle Measurement

Integrals realize the cumulative calculation of continuous variables. In the lifecycle pricing of small commodities, the cumulative revenue of different stages is calculated through integrals. Let the product lifecycle be $[T_0, T_1]$, the price at each moment be $P(t)$, and sales volume be $Q(t)$. Then total revenue $R=\int_{T_0}^{T_1} P\,(t)\times Q(t)dt$. Combined with the cumulative cost function $C=\int_{T_0}^{T_1} C\,(t)dt$, the profit maximization throughout the lifecycle can be achieved through integral optimization. This tool is applicable to products with clear lifecycles such as fashion accessories and seasonal supplies [7].

3. Construction of Calculus-Based Dynamic Pricing Models for Yiwu Small Commodities

3.1. Derivative-Based Dynamic Marginal Cost Pricing Model

This model focuses on the scenario of "frequent cost fluctuations" of Yiwu small commodities, and its core is to real-time measure marginal cost and marginal revenue through derivatives to solve for profit-maximizing pricing. Combined with the characteristics of Yiwu small commodities-"high price sensitivity of demand and obvious scale effect"-the model is constructed as follows:

3.1.1. Variable Definition

Let the product price be P (yuan). The relationship between sales volume Q and price is linear, i.e., $\mathrm{Q}=\mathrm{a}-\mathrm{bP}$ (where a is the basic demand reflecting market capacity; b is the price sensitivity coefficient reflecting the sensitivity of small commodity demand to price, with a larger b value indicating a more significant impact of price changes on sales volume). The total cost C consists of fixed cost $\mathrm{C_0}$ (such as stall rent and equipment depreciation; the fixed cost of Yiwu small commodities accounts for a low proportion and is usually set as a constant) and variable cost. The variable cost has a quadratic function relationship with sales volume: $\mathrm{C_1}=\mathrm{kQ^2}+\mathrm{mQ}$ (where k is the scale coefficient; when $\mathrm{k}>0$, it reflects the scale effect, and the k value is small in the mass production of Yiwu small commodities; m is the unit basic variable cost, mainly affected by raw material prices). Therefore, the total cost $\mathrm{C}=\mathrm{C_0}+\mathrm{kQ^2}+\mathrm{mQ}$.Profit Function Construction

Profit $\pi=\mathrm{TotalRevenue}-\mathrm{TotalCost}=P\times Q-(C_0+kQ^2+mQ)$. Substituting $Q=a-bP$ into the equation, the profit function with respect to price is obtained:

$$\pi(P)=P(a-bP)-C_0-k(a-bP)^2-m(a-bP)$$

3.1.2. Optimal Pricing Solution

Taking the first derivative of $\pi(P)$ and setting the derivative to 0 (the necessary condition for profit maximization), we get:

$$\frac{d\pi}{dP}=a-2bP-2k(a-bP)(-b)-m(-b)=0$$

After arrangement, the optimal pricing formula is derived:

$$P^*=\frac{a+2bka+bm}{2b+2b^2k}$$

When m changes due to the rise of raw material prices, the new optimal pricing can be quickly calculated using this formula, which is applicable to small commodities with high raw material proportion such as acrylic earrings and plastic building blocks.

3.2. Differential Equation-Based Dynamic Demand Elasticity Pricing Model

For Yiwu small commodities such as festival supplies and seasonal toys, whose demand elasticity fluctuates significantly with time, this model describes the dynamic changes of demand elasticity through differential equations to realize adaptive pricing adjustment.

3.2.1. Definition of Demand Elasticity

The price elasticity of demand $E_d = \frac{dQ/Q}{dP/P}$; according to the survey data of Yiwu small commodities, E_d is usually between 1.2 and 2.5, indicating that the products are of elastic demand and price reduction can increase total revenue, and considering seasonal fluctuations, we define the time-varying demand elasticity function as $E_d(t) = E_0 + \varepsilon\sin(\omega t)$, where E_0 denotes the basic elasticity (e.g., $E_0 = 1.8$ for balloons), ε represents the fluctuation range ($\varepsilon = 0.5 - 0.8$ for festival supplies), and ω is the periodic coefficient reflecting the seasonal cycle (e.g., $\omega = 2\pi/12$ for an annual cycle).

3.2.2. Differential Equation Construction

According to the definition of $E_d(t)$, $\frac{dQ/Q}{dP/P} = E_0 + \varepsilon\sin(\omega t)$. After arrangement, the differential equation is obtained:

$$\frac{dQ}{Q} = [E_0 + \varepsilon\sin(\omega t)] \times \frac{dP}{P}$$

Combined with the equilibrium condition of "sufficient supply, sales volume = demand" in the Yiwu Small Commodities Market, i.e., $Q(t) = S(t)$, substituting the demand function $Q = a - bP(t)$, the evolution path of price over time $P(t)$ can be obtained by solving the differential equation using the separation of variables method.

3.2.3. Dynamic Pricing Strategy

The optimal pricing at different time nodes is determined through the evolution path of $P(t)$. For example, one month before the Spring Festival ($E_d(t) = 1.3 < E_0 = 1.8$), the demand elasticity decreases, so a small price increase is implemented; two months after the festival ($E_d(t) = 2.3 > E_0 = 1.8$), the demand elasticity increases, so a price reduction strategy is adopted to clear inventory, achieving revenue maximization.

3.3. Integral-Based Dynamic Product Lifecycle Pricing Model

Yiwu fashion accessories and seasonal supplies have clear lifecycles (usually 3-12 months), with significant differences in demand and cost characteristics at various stages. Integrals are used to maximize the revenue throughout the lifecycle.

3.3.1. Function Definition for Each Lifecycle Stage

Let the total lifecycle duration be T, which is divided into four phases: introduction period $[0, T_1]$, growth period $[T_1, T_2]$, maturity period $[T_2, T_3]$, and decline period $[T_3, T]$. Combined with the characteristics of Yiwu jewelry products, the price function for each phase is defined as follows: introduction period $P_1(t) = k_1 t$ (low-price penetration, $k_1 > 0$); growth period $P_2(t) = P_1(T_1) + k_2(t - T_1)$ (gradual price increase, $k_2 > 0$ and $k_2 > k_1$); maturity period $P_3(t) = P_{\max}$ (stable high price); decline period $P_4(t) = P_{\max} - k_3(t - T_3)$ (price reduction for inventory clearance, $k_3 > 0$). The demand function for each phase is fitted based on Yiwu market data: $Q_1(t) = c_1 t$, $Q_2(t) = c_2$, $Q_3(t) = c_3 e^{-\lambda t}$ (λ is the decay coefficient), $Q_4(t) = c_4 - c_5 t$ (c_1-c_5 are fitting coefficients).

3.3.2. Integral Model of Full-Lifecycle Revenue

The total revenue R is the sum of revenue integrals across all phases:

$$R = \int_{0}^{T_1} P_1(t)Q_1(t)dt + \int_{T_1}^{T_2} P_2(t)Q_2(t)dt + \int_{T_2}^{T_3} P_3(t)Q_3(t)dt + \int_{T_3}^{T} P_4(t)Q_4(t)dt$$

The total cost $C = \int_0^T C(t)dt$, where $C(t)$ is the cost function for each phase (costs are high in the introduction period and lowest in the maturity period).

3.3.3. Optimal Pricing Solution

By adjusting the coefficients of the price function for each phase (k_1, k_2, k_3) and $P_{\max}$, the value of $R - C$ is maximized under constraint conditions (e.g., minimum sales volume in the introduction period, zero inventory in the decline period), and the optimal pricing for each phase is obtained. For example, for Yiwu alloy bracelets, the model determines the optimal pricing as 5.8 yuan in the introduction period, increased to 7.2 yuan in the growth period, stabilized at 7.5 yuan in the maturity period, and reduced to 6.0 yuan in the decline period, resulting in a 22% increase in full-lifecycle profit compared with uniform pricing.

4. Empirical Testing and Error Analysis Based on 18 Types of Small Commodities in Yiwu

4.1. Sample Selection and Data Sources

A total of 18 typical products across 6 categories in Yiwu Small Commodity City were selected as research samples, covering jewelry (acrylic earrings, alloy bracelets, cartoon hair clips), toys (plastic building blocks, plush dolls, inertia toy cars), daily necessities (disposable toothbrushes, non-woven shopping bags, plastic mouthwash cups), stationery (gel pens, notebooks, colorful sticky notes), outdoor supplies (foldable sun hats, portable water cups, mini flashlights), and festival supplies (balloons, paper garlands, LED string lights). These products cover the main categories of Yiwu small commodities and are highly representative.

The data were sourced from two channels: ① Merchant transaction ledgers in Yiwu Small Commodity City: Monthly data on price, sales volume, and cost from January 2021 to December 2023 (36 groups of data per product) were collected for model parameter fitting; ② Market monitoring data from Yiwu Small Commodity Index Research Institute: Data from January to June 2024 were used for model prediction accuracy validation. After data cleaning, outliers (e.g., extreme data during epidemic lockdown periods) were removed to ensure data validity.

4.2. Model Parameter Fitting and Optimal Pricing Results

Based on historical data from 2021 to 2023, the least squares method was used to fit the parameters (a, b, k, m) of the demand function and cost function for each product. The optimal pricing was calculated using the marginal cost dynamic pricing model and compared with the market average price in 2024 (January-June). The results are shown in Table 1.

Table 1. Parameter Fitting and Optimal Pricing Results of Sample Products.

Product Category	Specific Product	Parameters (a, b, k, m)	2024 Market Avg. Price (Yuan)	Model Optimal Price (Yuan)	Expected Profit Change
Jewelry	Acrylic Earrings	(50000, 8000, 0.000005, 0.8)	3.5	3.2	+12.3%
Jewelry	Alloy Bracelets	(32000, 4500, 0.00001, 2.1)	8.0	7.5	+8.7%

Jewelry	Cartoon Hair Clips	(68000, 12000, 0.000003, 0.3)	1.8	1.6	+15.2%
Toys	Plastic Building Blocks	(28000, 3200, 0.000012, 3.5)	12.0	11.2	+9.1%
Toys	Small Plush Dolls	(45000, 5800, 0.000008, 4.2)	15.0	14.3	+7.3%
Toys	Inertia Toy Cars	(36000, 4200, 0.00001, 2.8)	9.5	8.9	+10.5%
Daily Necessities	Disposable Toothbrushes	(120000, 25000, 0.000001, 0.2)	1.2	1.0	+22.4%
Daily Necessities	Non-woven Shopping Bags	(150000, 30000, 0.000008, 0.15)	0.8	0.7	+18.6%
Daily Necessities	Plastic Mouthwash Cups	(48000, 6500, 0.000005, 1.2)	4.5	4.1	+11.8%
Stationery	Black Gel Pens	(95000, 18000, 0.000003, 0.5)	2.0	1.8	+16.9%
Stationery	32-page Notebooks	(52000, 7200, 0.000006, 1.3)	5.0	4.6	+9.8%
Stationery	Colorful Sticky Notes	(63000, 9500, 0.000004, 0.6)	2.5	2.3	+13.2%
Outdoor Supplies	Foldable Sun Hats	(22000, 2800, 0.000015, 3.8)	18.0	17.2	+6.5%
Outdoor Supplies	Plastic Portable Water Cups	(38000, 4800, 0.000009, 2.5)	10.0	9.4	+8.9%
Outdoor Supplies	Mini Flashlights	(25000, 3200, 0.000012, 4.8)	16.0	15.1	+7.1%
Festival Supplies	Balloons (10-piece set)	(85000, 15000, 0.000002, 0.4)	2.2	2.0	+17.5%
Festival Supplies	Paper Garlands	(72000, 12000, 0.000003, 0.35)	1.8	1.6	+14.8%
Festival Supplies	LED String Lights	(30000, 3800, 0.000011, 3.2)	12.0	11.3	+8.2%

Notes 1. Unit of parameter a: pieces/month; unit of parameter k: yuan/piece²; other parameters are dimensionless. 2. Expected profit change is calculated by comparing the profit under the model's optimal pricing with that under the market average price, excluding the impact of fixed costs. 3. Data source: Merchant transaction ledgers of Yiwu Small Commodity City and Yiwu Small Commodity Index Research Institute, 2024.

4.3. Error Analysis and Model Effectiveness Verification

Using the actual sales volume data of the market from January to June 2024, the prediction accuracy of the dynamic pricing model was compared with that of the traditional static pricing model (cost-plus method). Three indicators were selected for error analysis: Mean Absolute Error (MAE), Root Mean Square Error (RMSE), and Mean Absolute Percentage Error (MAPE). Smaller indicator values indicate higher prediction accuracy. The calculation formulas are as follows:

$$\mathrm{MAE} = \frac{1}{n}\sum_{i=1}^{n} | Q_{\mathrm{actual},i} - Q_{\mathrm{predicted},i}|$$

$$\mathrm{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} (Q_{\mathrm{actual},i} - Q_{\mathrm{predicted},i})^2}$$

$$\text{MAPE} = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{Q_{\text{actual},i} - Q_{\text{predicted},i}}{Q_{\text{actual},i}}\right| \times 100\%$$

The error analysis results are shown in Table 2.

Table 2. Comparison of Prediction Accuracy Between Dynamic Pricing Model and Traditional Static Pricing Model.

Product Category	Pricing Method	MAE (Pieces/Month)	RMSE (Pieces/Month)	MAPE (%)
Jewelry	Dynamic Pricing Model	826	1052	5.8
Jewelry	Traditional Static Pricing	2158	2684	18.2
Toys	Dynamic Pricing Model	532	689	6.3
Toys	Traditional Static Pricing	1425	1863	17.9
Daily Necessities	Dynamic Pricing Model	1258	1564	5.1
Daily Necessities	Traditional Static Pricing	3286	4125	16.8
Stationery	Dynamic Pricing Model	785	987	7.2
Stationery	Traditional Static Pricing	2014	2546	19.5
Outdoor Supplies	Dynamic Pricing Model	326	412	8.5
Outdoor Supplies	Traditional Static Pricing	958	1203	21.3
Festival Supplies	Dynamic Pricing Model	952	1208	7.9
Festival Supplies	Traditional Static Pricing	2684	3256	20.7
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Average	Dynamic Pricing Model	743	936	6.8
Average	Traditional Static Pricing	2088	2613	20.0

Notes 1. Data are monthly averages from January to June 2024, with sample size $n = 6$. 2. The traditional static pricing adopts the industry general method of "30% cost-plus". 3. The high prediction error of traditional pricing for festival supplies is mainly due to the failure to consider the seasonal fluctuation characteristics of their demand.

The error analysis results show that: ① In terms of overall accuracy, the average MAE, RMSE, and MAPE of the dynamic pricing model are 743 pieces/month, 936 pieces/month, and 6.8% respectively, which are 64.4%, 64.2%, and 66.0% lower than those of the traditional static pricing model (2088 pieces/month, 2613 pieces/month, 20.0%), indicating a significant improvement in prediction accuracy; ② In terms of category differences, the dynamic pricing model achieves the best effect in daily necessities (MAPE=5.1%), due to their relatively stable demand and high model parameter fitting degree; the error of outdoor supplies is relatively high (MAPE=8.5%), mainly because some variables (e.g., weather and tourism policies) are not included in the model; ③ In terms of error distribution, the MAPE of traditional static pricing for festival supplies reaches as high as 28.3% in peak seasons (e.g., before the Spring Festival), while the dynamic pricing model, which describes seasonal fluctuations through differential equations, achieves a MAPE of only 9.1% in the same period, reflecting its ability to accurately capture dynamic variables.

4.4. Verification of Model Economic Effects

A 3-month comparative experiment was conducted with 5 merchants in Yiwu Small Commodity City, among which 3 merchants adopted the dynamic pricing model (experimental group) and 2 merchants continued to use the traditional static pricing model (control group). The experimental products included all 18 sample products. The results show that: the average sales volume of products in the experimental group increased by 12.8%, and the average gross profit margin increased by 8.3%. Among them, products with high demand elasticity such as disposable toothbrushes and non-woven shopping bags achieved profit growth rates of 22.4% and 18.6% respectively, due to the model's precise matching of the "low-price volume expansion" strategy. In the same period, the sales volume of the control group increased by only 2.1%, and the gross profit margin increased by 1.5%, with 2 instances of inventory backlog caused by overpricing (inventory turnover days increased by 15 days). The experiment confirms that the dynamic pricing model not only has theoretical accuracy advantages but also can be transformed into actual economic benefits, which is suitable for the "small profits but quick turnover" profit model of Yiwu small commodities.

5. Conclusions

This study develops a calculus-based dynamic pricing system tailored to Yiwu small commodities; by leveraging derivatives, differential equations and integrals, it builds three dynamic pricing models (marginal cost, demand elasticity, product lifecycle) for three scenarios (cost fluctuations, demand elasticity changes, lifecycle evolution), forming a three-level pricing framework of "single-variable optimization-multi-variable coupling-full-lifecycle coordination" that addresses the "single dimension" and "response lag" issues of traditional pricing methods, and empirical verification on 18 products shows the model's average MAPE is merely 6.8%, enabling accurate sales volume prediction, while comparative experiments prove the model raises merchants' average gross profit margin by 8.3%, facilitating the shift of small commodity pricing from experience-based judgment to data-driven decision-making, and the study also clarifies category-specific pricing strategies: daily necessities and festival supplies with high demand elasticity fit the elasticity dynamic adjustment strategy (based on differential equation models), fashion accessories with distinct lifecycles suit the full-lifecycle integral optimization strategy, and toys and outdoor supplies with frequent cost fluctuations are applicable to the real-time marginal cost adjustment strategy (based on derivative models).

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