

Design and Empirical Study of an Intelligent Operation System for Multi-Category Retail Stores

Li Li¹

¹ Tibet Xiaozehao Trading Co., Ltd., Hubei 430014, China

Correspondence: Li Li, Tibet Xiaozehao Trading Co., Ltd., Hubei 430014, China.

doi:10.63593/IST.2788-7030.2025.10.002

Abstract

Multi-category retail chains currently face core challenges such as “shift scheduling based on experience, display optimization without data support, and inefficient store inspections.” These issues are exacerbated by the lack of a universal operation tool, resulting in a 30% lower labor efficiency compared to single-category benchmark stores. This study addresses these practical pain points by designing an intelligent operation system for multi-category retail stores named “Store Efficiency Communicator” (SEC). The system comprises three core modules: “intelligent shift scheduling,” “heat map display optimization,” and “digital store inspection.” It innovatively incorporates an “industry-defined weight mechanism” to accommodate differences across categories such as jewelry, clothing, and cosmetics. Empirical tests in 10 multi-category stores in Wuhan demonstrated that the system improved labor efficiency by an average of 28% (28% for jewelry stores, 28% for clothing stores, and 26% for cosmetics stores), increased display area sales by 37% (40% for jewelry stores, 35% for clothing stores, and 36% for cosmetics stores), and raised compliance pass rates by 23 percentage points. The proposed “digital lightweight path for small and medium-sized retail chains” has been validated through the regional agency system of Chow Tai Fook and can be adapted to American small and medium-sized retail brands, providing practical references for the implementation and export of Chinese retail digital technology.

Keywords: multi-category retail stores, intelligent retail operation system, industry-defined weights, intelligent shift scheduling, heat map display, digital store inspection, small and medium-sized retail chains, cross-category adaptation, retail digitalization

1. Introduction

1.1 Research Background

The global retail industry is accelerating its transition from “traditional experience-driven” to “data intelligence-driven,” with the operational challenges of multi-category retail stores being particularly prominent. These stores, which cover a range of complementary business formats such as jewelry, clothing, and cosmetics, face three major operational difficulties. First, shift scheduling relies on the subjective experience of store managers. During peak customer flow periods such as wedding seasons and seasonal changes, there is often a situation where “one employee serves eight customers,” resulting in a sales loss rate of 15%. In contrast, during off-peak periods, there is a waste of labor, with labor costs exceeding 25% of revenue. Second, display optimization lacks data support. In 60% of the cooperating stores, display adjustments are still based solely on “visual aesthetics.” The conversion rate of display positions in corners and other slow-selling areas is less than 3%, and high-value products (such as diamond rings) suffer sales losses of over 30% due to improper display positions. Third, the store inspection process is inefficient. Traditional paper-based store inspections take an average of 4 hours per store, with non-standard problem recording and no closed-loop rectification. In 2022, penalties from non-compliance accounted for 18% of the annual losses of cooperating small and medium-sized retail enterprises.

The “Multi-Category Retail Store Operation Efficiency Report” released by the China Chain Store and Franchise Association in 2023 further validated these pain points. The average labor efficiency of multi-category stores is 30% lower than that of single-category benchmark stores, with a sales contribution difference of 45% in display areas. Only 30% of small and medium-sized retail chains have achieved cross-store operational data collaboration. Against this backdrop, there is an urgent need for a universal and lightweight intelligent operation system to solve the difficulties of multi-category stores in “standardization, low efficiency, and high costs.”

1.2 Research Significance

1.2.1 Theoretical Significance

This study fills the research gap of a “universal retail operation system for all categories.” Existing research mostly focuses on digital tools for single categories (such as jewelry or clothing). Based on cross-category practical experience in jewelry retail, clothing chains, and cosmetics stores, this study proposes an “industry-defined weight mechanism” to provide a replicable theoretical framework for the design of multi-category retail operation systems. Additionally, by combining the operational data of 190 Chow Tai Fook stores, a “multi-category store operation index improvement model” is established to enrich the empirical research system of retail digital operations.

1.2.2 Practical Significance

This study provides a low-cost implementation path for small and medium-sized retail chains. The deployment cost of the “Store Efficiency Communicator” system is 60% lower than that of traditional ERP systems (the deployment cost for 10 stores is controlled within 200,000 yuan), and no professional IT team is required for maintenance. After a pilot test in 10 cooperating stores in Hubei region of Chow Tai Fook in 2024, the system was quickly promoted to 30 stores. Moreover, the system’s cross-regional adaptability has been preliminarily verified. In 2025, during the testing phase, it can meet the operational needs of Los Angeles clothing chains and New York home stores, providing a practical sample for the export of Chinese retail digital technology. (Bastl, M., & Van der Vorst, J. G. A. J., 2011)

2. Design of the “Store Efficiency Communicator” System

2.1 System Objectives and Architecture

2.1.1 Core Objectives

Based on the operational requirements of Chow Tai Fook’s regional agency, the system sets the objectives of “three improvements and one reduction”: labor efficiency improvement of $\geq 25\%$ (referencing the labor efficiency level of Chow Tai Fook’s benchmark stores), display area sales improvement of $\geq 30\%$ (targeting slow-selling display positions), compliance pass rate of $\geq 95\%$ (reducing shopping center penalties), and labor cost reduction of $\geq 15\%$ (optimizing shift scheduling redundancy).

2.1.2 Lightweight Architecture

The system adopts a three-layer architecture of “cloud–middleware–front-end” to match the technological capabilities of small and medium-sized retail enterprises. The cloud uses Alibaba Cloud RDS database (in compliance with the “Personal Information Protection Law” to ensure the security of customer consumption data and store operation data). The middleware integrates the “industry-defined weight engine” and the “data fusion engine” (synchronizing real-time customer flow, sales, and compliance data from over 100 stores with a delay of ≤ 10 minutes). The front-end is divided into store and headquarters ends. The store end supports tablet or computer web login (no need to install dedicated software, and can be mastered within one hour) to complete shift scheduling, display analysis, and store inspection operations. The headquarters end can achieve data monitoring, index configuration, and permission management to meet the needs of large-scale control of multiple stores.

2.2 Core Module Design

2.2.1 Intelligent Shift Scheduling Module

Based on the practical logic of “customer flow prediction–labor matching–performance association,” this module addresses the pain point of “lack of labor during peak periods and idle labor during off-peak periods” in Chow Tai Fook’s agency stores.

- 1) **Customer Flow Prediction:** The module integrates the store’s historical customer flow data over the past 12 months (categorized by “hour–date–holiday”), category characteristics (for example, during the jewelry wedding season (February to May), the customer flow increases by 40%, and during the clothing seasonal change (March to April, September to October), the customer flow increases by 35%), and regional business district attributes (for example, in Wuhan Guanggu business district, the weekend customer flow accounts for 45%). Using the ARIMA time series model, it predicts the hourly customer flow for the next 7

days. The model training does not require professional data personnel. The system can automatically optimize parameters after importing the historical customer flow data of Chow Tai Fook stores in bulk through Excel.

- 2) **Labor Matching:** A universal benchmark threshold of “one employee for every 50 customers” is set, while also supporting adjustments by category. For example, the jewelry category, with a high average transaction value (over 5,000 yuan) and a long service duration (15 minutes per customer on average), adjusts the threshold to “one employee for every 30 customers.” After the application in Wuhan Guanggu Chow Tai Fook store in 2024, the sales loss rate during the wedding season weekend dropped from 15% to 5%.
- 3) **Performance Association:** The system automatically captures the transaction data of employees during peak customer flow periods, providing data support for the performance indicators in the “industry-defined weight mechanism.” The average monthly transactions per employee in Chow Tai Fook stores increased from 8 to 10.2.

2.2.2 Heat Map Display Module

Centered on customer behavior data, this module solves the problem of “experience-based display and difficulty in optimizing slow-selling items,” forming a closed loop of “data collection–heat map analysis–solution output–effect tracking.”

- 1) **Data Collection:** Utilizing the existing cameras in stores for data desensitization (only identifying customer stay areas without collecting facial information), it captures three types of data: “customer stay duration (over 2 minutes is considered an effective stay), stay area, and product touch frequency.” There is no need for additional hardware installation, reducing the investment cost for small and medium-sized stores.
- 2) **Heat Map Analysis:** Generate a ‘Display Area Heat Map’, marking areas with ‘red (high-value area, effective dwell ratio $\geq 60\%$), yellow (medium-value area, effective dwell ratio $30\%-60\%$), blue (low-value area, effective dwell ratio $<30\%$)’. According to 2024 data from the Chow Tai Fook store in Wuhan Tiandi, the first 3 meters of the main aisle are red zones, and the corner display stands are blue zones.
- 3) **Solution Output:** Based on category characteristics, optimization suggestions are generated. For example, in jewelry stores, high-value diamond rings are moved from blue areas (corner display tables) to red areas (try-on areas); in clothing stores, the current season’s new arrivals are moved from the second floor to the red area (entrance); in cosmetics stores, popular free samples are moved to the red area (checkout counter).
- 4) **Effect Tracking:** The system automatically tracks the sales changes over the next 30 days after the adjustment. For example, in Wuhan Tianhe Chow Tai Fook store, the monthly sales of diamond rings increased from 18 to 25 pieces, and in Wuhan Chuhe Hanjie clothing store, the monthly sales of new arrivals increased from 320 to 432 pieces.

2.2.3 Digital Store Inspection Module

Aiming at the pain point of “difficult store inspections for 190 branches” in Chow Tai Fook’s regional agency, a four-step process of “headquarters initiation–store execution–problem rectification–headquarters verification” is constructed.

- 1) **Store Inspection Task Initiation:** Chow Tai Fook’s regional agency headquarters configures the store inspection checklist by category. For example, the general items include hygiene compliance and service standards (such as employee appearance), while category-specific items include the verification of precious metal traceability labels in jewelry stores and product expiration date checks in cosmetics stores. The inspection frequency can be set to once a week.
- 2) **Store Execution:** The store inspectors log in by scanning the store QR code with a tablet and check each item on the list. For problem items (such as missing jewelry labels), they take photos and upload them while marking the “problem type.” In 2024, the pilot store’s inspection time was reduced from 4 hours per store to 1 hour per store.
- 3) **Problem Rectification:** The system automatically assigns problems to the store manager, with a 24-hour rectification deadline. After the manager completes the rectification, they upload rectification photos (such as attaching jewelry traceability labels).
- 4) **Headquarters Verification:** The regional agency’s store inspection specialist verifies the rectification effect online. If the verification is passed, the loop is closed; otherwise, it is returned for re-rectification. The pilot store’s problem rectification closure rate increased from 50% to 98%, and no stores were penalized by shopping centers for non-compliance from April to June 2024.

2.3 Industry-Defined Weight Mechanism

To address the differences in operational indicators across categories such as jewelry, clothing, and cosmetics, an

innovative “basic indicators + category-defined indicators” weight system is constructed to achieve “one system for multiple categories.”

- 1) **Basic Indicators (Weight 60%):** Fixed as “labor efficiency (30%) + compliance pass rate (30%)” to ensure consistent core operational goals for multi-category stores.
- 2) **Category-Defined Indicators (Weight 40%):** Configured by the headquarters (such as Chow Tai Fook’s regional agency headquarters) according to needs to match the profit characteristics of different categories. For example, the jewelry category is linked to “high-value product transaction rate (20%) + custom order completion rate (20%)” (custom diamond rings account for 25% of revenue in Chow Tai Fook); the clothing category is linked to “add-on rate (25%) + inventory turnover rate (15%)” (clothing faces significant inventory pressure during seasonal changes); the cosmetics category is linked to “membership card opening rate (20%) + free sample usage conversion rate (20%)” (cosmetics members contribute over 60% to repeat purchases).
- 3) **Technical Implementation:** The headquarters can directly adjust the weight ratio of category-defined indicators in the system’s “indicator configuration” module through drag-and-drop, without modifying the code. After Chow Tai Fook’s regional agency headquarters adjusted the jewelry category indicators, the data dashboard of 30 stores was refreshed in real-time to ensure consistent indicator understanding.

3. Cross-Industry Empirical Analysis (10 Stores in Wuhan)

3.1 Empirical Design

3.1.1 Sample Selection

Following the principles of “practical representativeness and category coverage,” the samples were selected from the stores cooperating with the author’s responsible Chow Tai Fook Hubei regional agency and related enterprises:

- 1) **Jewelry Stores (3):** Chow Tai Fook Guanggu World City Store, Chow Tai Fook Wuhan Tianhe Store, Chow Tai Fook Chuhe Hanjie Store, all of which were branches expanded after 2019, with a single store area of 50-80square meter and 8-12 employees.
- 2) **Clothing Stores (4):** Four stores of the local Wuhan clothing chain brand “Yixiang Liying” –Jiangnan Road Store, Guanggu Store, Xudong Store, and Nanhu Store, with a single store area of 30-60square meter and 5-8 employees.
- 3) **Cosmetics Stores (3):** Three stores of the domestic cosmetics collection store “Yanli” –Wuhan Tianhe Store, Jiangnan Road Store, and Guanggu Store, with a single store area of 20-40square meter and 5-6 employees.

3.1.2 Data Collection and Indicator Definition

- 1) **Data Collection:** A dual-source verification method of “system logs + store ledgers” was used. The system automatically captured customer flow, sales, and store inspection data from January to March 2024 (before application) and from April to June 2024 (after application). The stores provided corresponding labor cost and compliance penalty records during the same period to ensure data authenticity (for example, the sales data of Chow Tai Fook stores were reconciled with the ERP system).
- 2) **Core Indicators:** Labor efficiency (monthly store sales / average number of employees per month, unit: ten thousand yuan / person), display area sales (the total monthly sales of all display areas in the store, excluding custom orders directly shipped from the warehouse), compliance pass rate (monthly passed store inspection items / total monthly store inspection items $\times$ 100%), labor cost ratio (monthly store labor cost / monthly store sales $\times$ 100%).

3.2 Empirical Results

3.2.1 Overall Indicator Improvement

After the application of the system, the core indicators of the 10 stores all significantly exceeded the preset targets, and operational efficiency was significantly improved:

Table 1.

Core Indicator	Pre-Application Mean	Post-Application Mean
Labor Efficiency (ten thousand yuan/person)	4.2	5.38
Display Area Sales (ten thousand yuan/month)	18.5	25.35

Compliance Pass Rate (%)	75	98
Labor Cost Ratio (%)	26	22.1

3.2.2 Category-Specific Indicator Differences

Due to different operational characteristics, there are reasonable differences in the improvement of indicators across categories, but all have achieved significant improvements:

Table 2.

Category	Labor Efficiency Improvement	Display Sales Improvement	Compliance Pass Rate Improvement
Jewelry	28%	40%	22 percentage points
Clothing	28%	35%	24 percentage points
Cosmetics	26%	36%	23 percentage points

3.3 Result Analysis

3.3.1 Core Driver of Labor Efficiency Improvement

The precise matching of “customer flow–labor” in the intelligent shift scheduling module is the key. Before the application, during the wedding season weekend peak in Guanggu Chow Tai Fook store, there was a situation of “one employee serving eight customers,” with customer waiting time exceeding 20 minutes and a sales loss rate of 15%. After the application, based on the customer flow data predicted by the ARIMA model, the system automatically increased two employees during peak hours, reducing the waiting time to within 5 minutes and the loss rate to 5%. Meanwhile, one employee was reduced during off-peak hours, reducing the labor cost ratio from 26% to 22.1%, achieving the dual goals of “improved labor efficiency and cost control.” (Hübner, A., & Hammerschmidt, M., 2014)

3.3.2 Logic of Display Sales Improvement

The “data-driven optimization” of the heat map display module solved the blindness of traditional display. Before the application, in Wuhan Tianhe Chow Tai Fook store, diamond rings were displayed in the corner display table (blue area), with a monthly transaction of 18 pieces. After the application, according to the heat map, they were moved to the try-on area (red area), increasing the customer stay time from 1 minute to 3 minutes and the try-on rate from 20% to 45%, resulting in a monthly transaction increase to 25 pieces (+39%). In “Yixiang Liying” Jiangnan Road store, the current season’s new arrivals were moved from the second floor (blue area) to the entrance on the first floor (red area), increasing the monthly sales of new arrivals from 80,000 yuan to 108,000 yuan (+35%), verifying the guiding value of data for display optimization.

3.3.3 Reason for Compliance Pass Rate Improvement

The “closed-loop management” of digital store inspection solved the rectification problem. Before the application, the paper-based store inspection records were not standardized, and problem rectification relied on the store manager’s awareness, with an average rectification time of 72 hours and a closure rate of only 50%. After the application, the system automatically reminded of the rectification deadline (24 hours) and required uploading rectification photos for online verification by the headquarters. In Wuhan “Yanli” cosmetics store, compliance problems caused by untimely expiration date checks decreased from 1-2 cases per month to zero. From April to June 2024, none of the 10 stores had any shopping center penalty records.

4. System Advantages and Cross-Regional Adaptability

4.1 Industry Comparison Advantages

Based on the selection practice of Chow Tai Fook’s regional agency, the “Store Efficiency Communicator” system was compared with mainstream retail operation systems such as Yonyou Retail ERP and Fubon Fusion. It was found that the system is more suitable for the needs of small and medium-sized retail chains in terms of “universality, lightness, and cost control”:

Table 3.

Comparison Dimension	“Store Efficiency Communicator” System	Existing Mainstream Systems
----------------------	--	-----------------------------

Category Adaptability	Supports 6 major categories (jewelry, clothing, cosmetics, etc.), no secondary development required	Supports only 1-2 categories, cross-category customization costs over 500,000 yuan
Deployment Cost	Within 200,000 yuan (for 10 stores)	Over 1,000,000 yuan (for 10 stores)
Implementation Cycle	7 days (cloud configuration + store training)	30-60 days (hardware installation + system debugging)
Operation Threshold	Store personnel can master within 1 hour (including Chow Tai Fook sales staff)	Requires professional IT personnel, training for over 7 days

4.2 Adaptability to the American Market

Based on the author's research on the American retail market, the "Store Efficiency Communicator" system can be adapted to the needs of American small and medium-sized retail brands through three adjustments:

- 1) **Customer Flow Prediction Adaptation:** A new "American holiday customer flow model" is added to adjust the customer flow peak threshold for American-specific consumption nodes such as Black Friday and Christmas season. For example, in a Los Angeles clothing chain, the customer flow during Black Friday exceeds three times the daily average, and the system automatically matches three times the labor force.
- 2) **Compliance Standard Adaptation:** A new "American retail compliance checklist" is added, covering customer data protection requirements under California's Consumer Privacy Law (such as encrypted storage of consumption data) and FDA labeling standards for cosmetics products (such as ingredient labeling). The headquarters can directly select and enable these without custom development.
- 3) **Data Deployment Adaptation:** Alibaba Cloud International is used for deployment to meet the requirements of data storage compliance in the United States (local data storage). The data synchronization delay is ≤ 15 minutes, supporting real-time control of stores in multiple regions such as Los Angeles and New York.

In January 2025, the system was tested in a medium-sized clothing chain in Los Angeles (with 5 stores). Initially, only the "customer flow prediction model" and "compliance checklist" were adjusted. Within 2 months, the labor efficiency of the stores increased by 22%, and the compliance pass rate increased from 80% to 96%. This verified the feasibility of cross-regional adaptation and laid the foundation for the overseas extension of related agency business of Chow Tai Fook. (Alfaro, J., & Corbett, C., 2003)

5. Conclusions and Future Outlook

5.1 Research Conclusions

- 1) **System Design Conclusion:** The "Store Efficiency Communicator" system, through its three core modules of "intelligent shift scheduling–heat map display–digital store inspection" and the "industry-defined weight mechanism," has achieved universal intelligent operation for multi-category retail stores. Its lightweight architecture (cloud deployment, low-threshold operation) and low-cost advantages (200,000 yuan for 10 stores) accurately meet the actual needs of small and medium-sized retail chains. After the application in 30 branches of Chow Tai Fook's Hubei region in 2024, the average operational efficiency increased by 30%.
- 2) **Empirical Effect Conclusion:** The empirical study in 10 multi-category stores in Wuhan showed that the system can effectively solve industry pain points – labor efficiency increased by an average of 28%, display area sales increased by 37%, and compliance pass rate increased by 23 percentage points. The adaptability to different categories (jewelry, clothing, cosmetics) is good, and the empirical results can be promoted to similar small and medium-sized retail chains.
- 3) **Industry Value Conclusion:** The proposed "digital lightweight path for small and medium-sized retail chains" (focusing on high-pain points, using cloud deployment, and implementing a "pilot – optimization – promotion" rhythm) has been verified through the regional agency system of Chow Tai Fook. It provides a practical digital solution for over 80% of small and medium-sized retail chains. Meanwhile, the adaptability of the system to the Chinese and American markets provides a practical sample for the export of Chinese retail digital technology.

5.2 Future Outlook

- 1) **System Iteration:** First, introduce an AI demand forecasting function to automatically recommend display adjustments and shift scheduling plans based on the sales data of 190 branches of Chow Tai Fook and industry trends. Second, expand the adaptation to heavy-experience retail categories such as fresh produce

and home goods to achieve the goal of “full retail category coverage.”

- 2) **Market Expansion:** Deepen cooperation in the American retail market by establishing long-term partnerships with Los Angeles clothing chains and New York jewelry retailers. Form a complete case of “Chinese technology + American scenarios” to support the overseas extension of related agency business of Chow Tai Fook.
- 3) **Theoretical Extension:** Based on empirical data from multiple regions and categories such as Wuhan and Los Angeles, construct a “multi-category retail digital operation effect evaluation model” to provide a more accurate prediction tool for the industry. Further refine the theoretical and practical system of retail digital operations.

References

- Alfaro, J., & Corbett, C., (2003). The value of SKU rationalization in practice: The pooling effect under suboptimal inventory policies and nonnormal demand. *Production and Operations Management*, 12(1), 12–29.
- Bastl, M., & Van der Vorst, J. G. A. J., (2011). Product variety and operational performance in retail: A configurational approach. *International Journal of Operations & Production Management*, 31(8), 838–863.
- Hübner, A., & Hammerschmidt, M., (2014). The dark side of product variety: How assortment size affects customer satisfaction in retailing. *Journal of Retailing and Consumer Services*, 21(5), 737–744.
- Gaur, V., & Kesavan, R., (2005). The impact of product variety on inventory productivity in retailing. *Management Science*, 51(10), 1496–1509.

Copyrights

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).