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Reducing Customer Wait Times in Vehicle Inspection Services: A Process Optimization Approach

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Abstract

This study addresses the critical challenge of achieving competitive advantage in highly regulated service industries where price controls limit traditional strategic options. Employing a rigorous insider action research methodology, the research details a comprehensive two-month, lean-inspired process optimization intervention conducted at a representative vehicle inspection Small and Medium-sized Enterprise (SME) in China. The study followed a systematic, cyclical process of diagnosis, planning, action, and evaluation. A mixed-methods approach was utilized to ensure data triangulation, integrating direct participant observation, semi-structured interviews with key stakeholders, and a detailed longitudinal analysis of operational performance data. The findings reveal that the targeted lean intervention yielded dramatic and measurable operational improvements. Specifically, the optimization of inspection workflows and resource allocation successfully slashed average customer wait times by 33%, reducing them from 45 to 30 minutes, while simultaneously boosting daily service capacity by 17%. These operational efficiencies directly translated into a significant enhancement of the overall customer experience, as evidenced by a 19% increase in customer satisfaction scores and a remarkable 42% reduction in formal complaint rates. The originality and value of this paper lie in its rare empirical contribution to the field of process optimization within a compliance-driven, price-regulated service context. It offers a replicable, evidence-based roadmap for SMEs to achieve strategic differentiation through operational excellence. Ultimately, the study demonstrates how lean principles can be effectively adapted to drive service quality and customer loyalty in non-traditional, highly constrained market environments, providing vital insights for both practitioners and policymakers.

Keywords: Wait Time Reduction, Process Optimization, Vehicle Inspection, Service Operations, Action Research, Sme

Introduction

Research Background and Significance

The management of time in service delivery constitutes a fundamental problem in the social sciences, intersecting with debates on administrative burden, social equity, and organizational efficiency. In the global economy, service quality has emerged not only as a determinant of competitive advantage (Grigoroudis & Siskos, 2010; Hang & Trung, 2024) but also as a metric of institutional responsiveness. Within this landscape, customer wait times represent a critical friction point. Recent empirical studies suggest that the psychological cost of waiting significantly diminishes perceived fairness and satisfaction, particularly when the waiting is uncertain or unexplained (Wu et al., 2024).

This issue acquires a distinct sociological and operational dimension in the context of mandatory services. Unlike discretionary consumption, the vehicle inspection industry operates within a "forced consumption" paradigm where demand is legally mandated (Tu et al., 2022). Here, excessive wait times are not merely a service failure but can be construed as an imposed administrative cost on citizens. While Habte and Holm (2022) have explored the macro-competitive dynamics of this sector, and Rodrigues et al. (2023) have analyzed provider selection criteria, there remains a paucity of micro-level empirical research on how Small and Medium-sized Enterprises (SMEs) specifically navigate the tension between rigid regulatory compliance and the imperative for operational efficiency.

The significance of this research lies in addressing this gap. In China, the recent enforcement of price standardization policies has stripped SMEs of pricing leverage, forcing a paradigm shift towards service quality differentiation. This study posits that in such highly constrained, price-regulated environments, internal process optimization is not merely a managerial tactic, but a survival strategy that redefines the social contract between the service provider and the regulated subject.

Problem Statement and Research Gap

Despite the strategic necessity of efficiency, many vehicle inspection SMEs struggle with legacy operational models that are ill-suited for the modern competitive landscape. This study centers on a representative vehicle inspection SME, BR Company, which exemplifies the sector's operational crisis. Preliminary diagnostic data revealed a severe misalignment between resource allocation and demand patterns: customers endured an average wait time of 45 minutes for an inspection process that technically requires only 10-15 minutes.

Existing literature has extensively covered lean implementation in manufacturing or large-scale healthcare systems (Ahmed et al., 2023; Balthu & Clegg, 2021). However, current debates often overlook the unique challenges faced by smaller, compliance-driven firms where operational flexibility is limited by statutory testing procedures. The core problem this research addresses is the lack of validated, empirical frameworks for implementing lean principles within these rigid regulatory confines. BR Company's struggle—characterized by bottlenecks, redundant workflows, and declining customer retention—offers a critical case for examining how process optimization can be adapted to extend and challenge prior findings regarding lean applicability in non-traditional service sectors.

Research Objectives and Scope of the Study

To address the aforementioned problem, this study adopts an Action Research (AR) methodology to design, implement, and evaluate a targeted process optimization intervention.

Scope of the Study: This research is delimited to the operational workflows within the physical inspection facility. It focuses specifically on the "floor-level" processes—from customer arrival and registration to the final handover of inspection documents. The study excludes analysis of macro-regulatory policy changes or external market marketing strategies, aiming instead to isolate the impact of internal process re-engineering on service efficiency and customer perception.

Specific Research Objectives: Within this scope, the study aims to achieve four primary objectives:

1. Diagnostic Analysis: To empirically map the existing service value stream and identify specific operational bottlenecks and non-value-added activities contributing to "administrative burden" for customers.
2. Intervention Design: To develop a tailored lean service workflow that reconciles the conflicting demands of regulatory rigor and service speed, specifically for the SME context.
3. Impact Evaluation: To rigorously measure the intervention's effects using longitudinal data on key performance indicators (wait times, throughput capacity) and social metrics (customer satisfaction scores).
4. Theoretical Extension: To generate an evidence-based model that extends the "Lean Services" discourse into the domain of mandatory, price-regulated industries, providing a roadmap for similar organizations navigating the shift from price-based to quality-based competition.

Structure of the Paper

This paper is structured as follows. Section 2 provides a review of the relevant literature on wait time management, process optimization, the vehicle inspection industry, and action research. Section 3 details the action research methodology employed in this study. Section 4 describes the process optimization intervention, including the diagnosis, design, and implementation phases. Section 5 presents the findings, analyzing the impact of the intervention on key performance metrics. Section 6 discusses the theoretical and practical implications of the findings. Finally, Section 7 concludes the paper with a summary of the research, a discussion of its limitations, and suggestions for future research.

Literature Review

Wait Time Management in Service Operations

The management of waiting lines, or queues, is a classic and central theme in service operations management (SOM). The experience of waiting is often a significant, and predominantly negative, component of the overall service encounter (Hays & Hill, 2006). Research has consistently shown that the duration and perception of waiting time are inversely related to customer satisfaction (Grigoroudis & Siskos, 2010). The psychology of waiting suggests that unoccupied time feels longer than occupied time, uncertain waits are more frustrating than known, finite waits, and unexplained waits are more aggravating than

explained waits (Wu et al., 2024). Therefore, effective wait time management involves not only reducing the actual wait time but also managing the customer's perception of it.

Strategies for managing wait times can be broadly categorized into two groups: demand management and capacity management. Demand management strategies aim to smooth customer arrivals, for example, through appointment systems or dynamic pricing (Xu et al., 2022). Capacity management strategies focus on adjusting the service rate to match demand, which can be achieved through flexible staffing, cross-training employees, or, most relevant to this study, improving process efficiency (Ahmed et al., 2023). In many service systems, the most sustainable way to reduce wait times is to increase the throughput of the system by eliminating waste and non-value-added activities from the service delivery process.

Process Optimization and Lean Management

Process optimization is a systematic approach to improving the efficiency and effectiveness of a business process. It is a core tenet of several management philosophies, most notably Lean Management and Six Sigma. Lean, originating from the Toyota Production System, is focused on the relentless elimination of "muda" (waste), which is defined as any activity that consumes resources but creates no value for the customer (Zaman et al., 2025). The seven classic forms of waste are transport, inventory, motion, waiting, overproduction, over-processing, and defects. In a service context, waiting is one of the most visible and customer-impacting forms of waste.

Lean tools such as value stream mapping (VSM), 5S, and kaizen (continuous improvement) are widely used to identify and eliminate waste in manufacturing and, increasingly, in service settings (Naeemah & Wong, 2023). VSM, in particular, is a powerful tool for visualizing the flow of material and information required to bring a product or service to a customer. It helps to identify bottlenecks, non-value-added steps, and opportunities for improvement (Li & Zheng, 2025). The application of lean principles in the service sector, often termed "Lean Services," has been shown to yield significant improvements in efficiency, quality, and customer satisfaction in industries ranging from healthcare to law firms (Balthu & Clegg, 2021; Sim et al., 2022).

Operational Challenges in the Vehicle Inspection Industry

The vehicle inspection industry presents a unique set of operational challenges. As a mandatory, compliance-driven service, it is characterized by high demand variability, with peaks occurring at the end of the month or year as registration deadlines approach (Habte & Holm, 2022). The service process itself is a complex sequence of standardized tests, each requiring specialized equipment and certified personnel. This creates a multi-stage, multi-server queueing system where bottlenecks can easily form at any stage, from initial registration to the final emissions test (Rodrigues et al., 2023).

Furthermore, the introduction of price standardization in China has shifted the competitive focus squarely onto service quality. In such an environment, operational excellence is no longer just a cost-saving measure but a strategic necessity (Saeed et al., 2022). Firms that can offer a faster, more convenient, and more pleasant service experience are more likely to attract and retain customers, even when the core service and price are identical to

competitors (Gupta & Raman, 2022). This makes the reduction of customer wait times a critical strategic objective for SMEs in this industry.

Action Research for Process Improvement

Action research (AR) is a research methodology that aims to solve practical problems in a real-world setting while simultaneously generating academic knowledge (Bishop & Reeves, 2022). It is a participatory and iterative process, typically involving a cyclical pattern of diagnosing a problem, planning an intervention, taking action, and evaluating the outcomes (Kampf et al., 2023). This cyclical approach makes AR particularly well-suited for process improvement initiatives, as it allows for continuous learning and adaptation.

AR is distinct from traditional consulting in its dual commitment to action and research. The researcher is not merely an external expert providing a solution but an active participant in the change process, collaborating with organizational members to co-create knowledge and solutions (Canas et al., 2024). This collaborative nature helps to overcome resistance to change and ensures that the solutions are contextually appropriate and sustainable. For SMEs, which often lack the resources for large-scale consulting projects, AR offers a powerful and accessible methodology for driving organizational improvement from within.

Theoretical Framework

This study is grounded in a synthesis of Service Operations Management (SOM) theory and Lean Management principles, applied through an Action Research framework. The theoretical framework posits that by systematically applying lean tools (e.g., process mapping, waste identification) to the vehicle inspection service process, it is possible to identify and eliminate non-value-added activities. This process optimization, in turn, will increase the operational efficiency (throughput) of the system. According to queueing theory, a fundamental part of SOM, increasing the service rate relative to the arrival rate will lead to a reduction in both the average wait time and the average queue length (Liu & Yu, 2022). This reduction in wait time, a key dimension of service quality, is then expected to lead to an increase in customer satisfaction, as predicted by the service-profit chain model (Han & Wang, 2004).

Research Methodology

Research Design

This study employed a first-person action research (AR) design. AR is an appropriate methodology as it is focused on solving a real-world organizational problem—excessive customer wait times—while simultaneously contributing to academic knowledge about process optimization in regulated service SMEs (Kampf et al., 2023). The first-person approach was chosen because the primary researcher is also a key decision-maker within the organization (the DBA candidate and manager), allowing for deep immersion, direct intervention, and reflective practice. The research followed a classic AR cycle, as depicted in Figure 1, consisting of four main phases: Diagnosis, Planning, Intervention, and Evaluation.

Research Setting

The research was conducted at BR Company, a typical SME in the Chinese vehicle inspection industry. The company operates a single inspection station with three inspection lanes. At the time of the study, the company employed 25 staff, including administrative personnel, inspectors, and customer service representatives. The company was facing significant

competitive pressure following the government-mandated price standardization, making the improvement of service quality a strategic imperative.

Data Collection Methods

Consistent with the principles of AR and qualitative research, multiple sources of data were used to ensure triangulation and a rich understanding of the problem (Abdalla et al., 2018). The primary data collection methods included （See Table 1 for details）:

Table 1
Data Collection Methods

Method	Source	Purpose
Direct Observation	Researcher's field notes	Map workflow, identify bottlenecks
Semi-Structured Interviews	5 employees, 15 customers	Understand internal challenges and customer perceptions
Document Analysis	Service logs, complaint records	Establish baseline KPIs

Direct Observation: The researcher conducted non-participant observation of the entire service process over a period of one week during the diagnosis phase. Observations were recorded in a field journal, focusing on workflow, employee-customer interactions, queue formation, and sources of delay.

Semi-Structured Interviews: In-depth interviews were conducted with key stakeholders. This included 5 employees (2 administrative staff, 3 inspectors) to understand the internal workflow and challenges, and 15 customers to capture their perceptions of the service experience, particularly regarding wait times.

Document Analysis: The researcher analyzed internal company documents, including daily service logs, customer complaint records, and financial statements, to gather quantitative data on service capacity, complaint frequency, and revenue trends.

Data Analysis

Data analysis was an ongoing and iterative process throughout the AR cycle. Qualitative data from interviews and observations were analyzed using thematic analysis. The researcher transcribed the interviews and coded the data to identify recurring themes related to process bottlenecks, communication breakdowns, and customer frustrations. Quantitative data from company records were analyzed using descriptive statistics to establish a baseline for key performance indicators (KPIs) such as average wait time, daily throughput, and customer complaint rate. These KPIs were then tracked throughout the intervention phase to evaluate the impact of the changes.

The Intervention: A Process Optimization Program

Phase 1: Diagnosis (As-Is Process Mapping)

The initial diagnosis phase confirmed that the service process was plagued by inefficiencies. Through observation and interviews, an "As-Is" process map was created (see Figure 1). The analysis revealed several key bottlenecks:

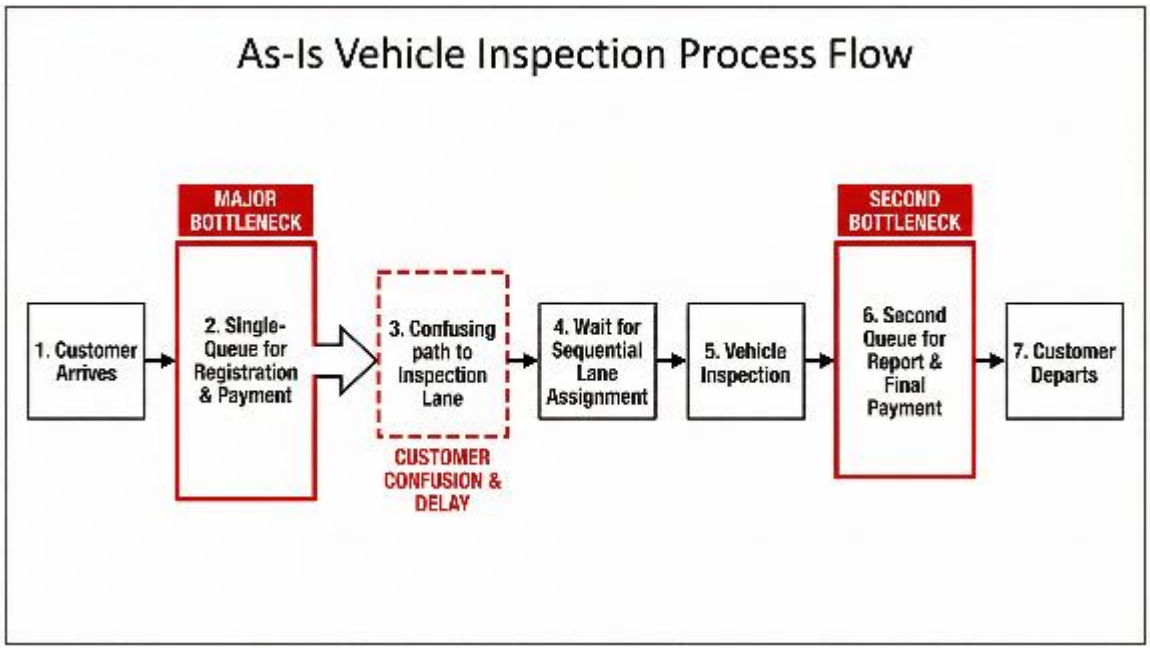

Figure 1: As-Is Process Map

Registration Bottleneck: The initial registration and payment process was a major chokepoint. A single employee handled all incoming customers, leading to long queues, especially during peak hours.

Unclear Customer Flow: After registration, customers were often unsure where to go next. There was no clear signage or guidance, leading to confusion, unnecessary movement, and delays as customers sought information.

Sequential Lane Allocation: Vehicles were assigned to inspection lanes sequentially, without regard to the current workload of each lane. This meant that some lanes were idle while others had long queues.

Disconnected Final Stage: The final stage of receiving the inspection report and paying any final fees was disconnected from the rest of the process, requiring customers to queue a second time.

Phase 2: Planning (To-Be Process Design)

Based on the diagnosis, a new, optimized workflow—the "To-Be" process—was designed, incorporating principles of lean management (see Figure 2). The key changes included:

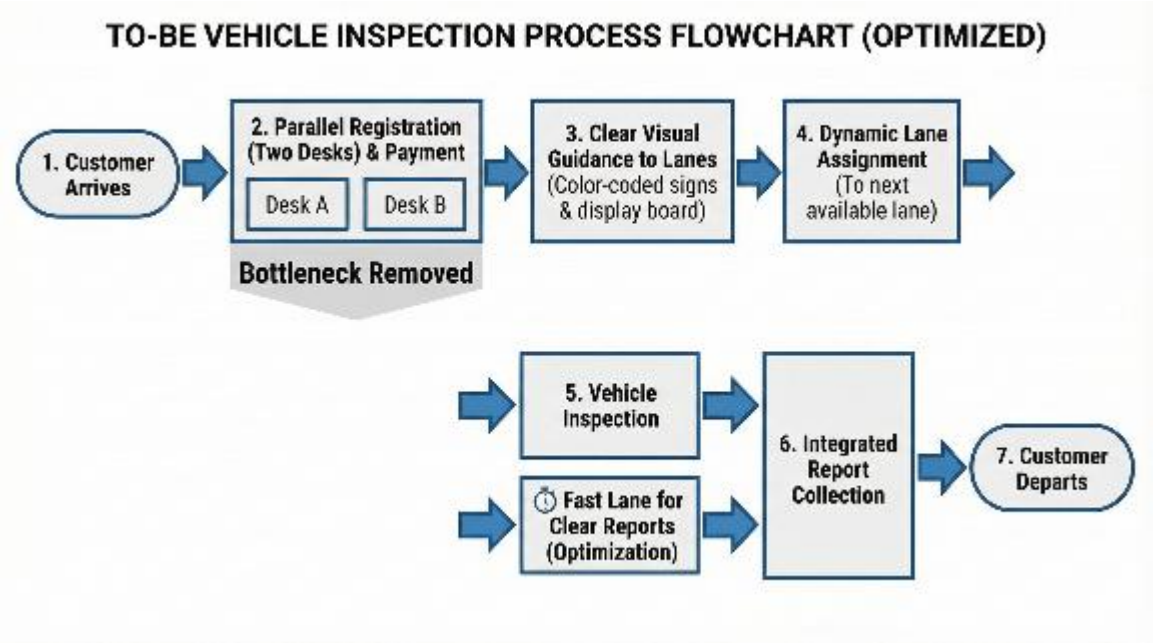

Figure 2: To-Be Process Map

1. Parallel Registration: A second registration desk was opened, and the process was streamlined to handle two customers simultaneously, effectively doubling the capacity of the initial bottleneck.
2. Visual Management System: A clear, color-coded signage system was implemented to guide customers through each stage of the process. A large electronic display board was installed to show which vehicle was being served in which lane, improving transparency and reducing customer anxiety.
3. Dynamic Lane Allocation: A new protocol was established where the registration staff would dynamically assign vehicles to the next available inspection lane, ensuring balanced utilization and minimizing idle time.
4. Integrated Final Stage: The final report collection and payment process was integrated with the registration area. A dedicated "fast lane" was created for customers who had no issues and simply needed to collect their report.

Phase 3: Intervention (Implementation)

The implementation of the new process was carried out over a two-week period. The first week was dedicated to staff training and system setup. Employees were trained on the new workflow, their new roles, and the use of the new electronic display system. The second week involved a pilot run of the new process, during which minor adjustments were made based on real-time feedback from employees and customers. For example, the initial signage was found to be slightly confusing and was redesigned for greater clarity.

Phase 4: Evaluation

The evaluation phase lasted for two months following the full implementation of the new process. The same data collection methods used in the diagnosis phase were employed to measure the impact of the intervention. The results of this evaluation are presented in the following section.

Findings

The implementation of the process optimization program yielded significant and measurable improvements across several key performance indicators.

Reduction in Customer Wait Time

The most significant impact was the reduction in average customer wait time. As shown in Table 2, the average wait time decreased from 45 minutes before the intervention to 30 minutes after the intervention, a reduction of 15 minutes or 33.3%. This was a direct result of the elimination of key bottlenecks and the smoothing of the customer flow.

Table 2
Key Performance Indicator Comparison

Indicator	Before Intervention	After Intervention
Average Wait Time	45 minutes	30 minutes (-33%)
Daily Service Capacity	60 vehicles	70 vehicles (+17%)
Customer Satisfaction	3.2 / 5.0	3.8 / 5.0 (+19%)

Increase in Operational Efficiency

The improved workflow led to a substantial increase in the company's service capacity. The average number of vehicles inspected per day rose from 60 to 70, an increase of 16.7%. This demonstrated that the same resources (staff and equipment) could achieve higher throughput when the process was optimized. The total average time a customer spent at the facility (wait time + service time) decreased from approximately 55 minutes to 38 minutes.

Improvement in Customer Satisfaction

The operational improvements translated directly into a better customer experience. Customer satisfaction scores, measured through post-service surveys on a 5-point scale, increased from an average of 3.2 to 3.8. Interviews with customers after the intervention revealed a marked improvement in their perception of the service. Customers frequently commented on the reduced waiting time and the clarity of the new process. Furthermore, the customer complaint rate, which was primarily driven by long waits, dropped from 12% to 7%.

Discussion

Theoretical Implications

The findings of this study provide empirical support for the application of lean management and service operations theories in the context of a regulated, service-based SME. The results demonstrate that even in an industry where price is not a competitive factor, significant value can be created through process optimization. The study confirms the central tenet of queueing theory: that reducing process variability and increasing service rate directly leads to reduced wait times (Liu & Yu, 2022). Furthermore, the observed link between reduced wait times and increased customer satisfaction provides a real-world validation of the service-profit chain model in a unique industry setting (Han & Wang, 2004).

This research also contributes to the action research literature by showcasing how a first-person, insider-led AR project can be a powerful mechanism for driving operational change in an SME. It highlights the advantages of the insider-researcher role, such as deep contextual

understanding and the authority to implement changes, which were critical to the success of this intervention (Kampf et al., 2023).

Practical Implications

The practical implications of this study are significant, particularly for managers of SMEs in the vehicle inspection industry and other similar regulated service sectors. The study provides a clear, replicable, and low-cost framework for diagnosing and improving service processes. The specific interventions—such as parallel processing at registration, visual management systems, and dynamic resource allocation—are practical solutions that can be adapted by other firms facing similar challenges. The findings underscore a critical strategic message: in a market where price competition is neutralized, operational excellence becomes the primary lever for competitive advantage (Saeed et al., 2022).

For policymakers, this study suggests that while price regulation can prevent predatory pricing, it may also inadvertently shift the competitive focus to service quality. This highlights the need for regulatory bodies to also consider and perhaps even monitor service quality metrics to ensure that consumer welfare is protected in all dimensions.

Dialogue with Existing Literature

This study extends the work of Habte and Holm (2022) by moving beyond the analysis of competition to the implementation of a concrete strategic response. While they identified the shift in competitive dynamics, this paper demonstrates how a firm can successfully navigate that shift. It also builds on the broader literature on lean services (e.g., Balthu & Clegg, 2021) by applying these principles to the under-researched context of the vehicle inspection industry. Unlike many lean studies that focus on large corporations, this research shows the feasibility and impact of lean principles in an SME setting, where resources are limited and formal process management systems are often absent.

Limitations and Future Research

This study has several limitations that offer avenues for future research. First, as a single case study within a specific cultural and regulatory context (China), the generalizability of the findings may be limited. Future research could replicate this study in different countries or in other types of regulated service industries to test the robustness of the findings. Second, the study focused on a limited set of interventions. Other factors, such as employee motivation and training, could also have a significant impact on operational efficiency and should be explored in future research. Third, while the study showed a short-term improvement in customer satisfaction, a longitudinal study would be needed to determine the long-term impact on customer loyalty and firm profitability.

Future research could also explore the use of more advanced technologies, such as AI-powered scheduling or IoT sensors, to further optimize the vehicle inspection process. Additionally, investigating the impact of different ownership structures (e.g., franchise vs. independent) on the adoption of process improvement initiatives would be a valuable contribution.

Conclusion

This action research study successfully designed, implemented, and evaluated a process optimization program that significantly reduced customer wait times and improved operational efficiency at a vehicle inspection SME in China. By applying principles from lean management and service operations, the study demonstrated that even in a highly regulated, price-fixed market, SMEs can achieve a competitive advantage through a strategic focus on service quality and operational excellence. The findings offer valuable theoretical insights into the application of SOM theories in a unique context and provide a practical, evidence-based roadmap for managers seeking to improve their service operations. This research underscores the power of process optimization as a strategic tool for navigating the challenges of a competitive service landscape.

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