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Improving Inventory Record Accuracy in Retail Operations Through Lean Six Sigma: A DMAIC-Based Framework

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Abstract. Inventory record inaccuracy separates system balances from physical stock and weakens retail replenishment, shelf availability, and customer service. This study proposes a focused Lean Six Sigma framework for improving inventory record accuracy in retail operations. A structured narrative review of fourteen academic sources was used to synthesize evidence on error causes, operational consequences, auditing, process discipline, radio-frequency identification, and data-based detection. The analysis organizes these findings through Define, Measure, Analyze, Improve, and Control. It links receiving errors, unrecorded shrinkage, misplacement, transaction delay, and incorrect adjustments with process mapping, stratified physical audits, Pareto analysis, cause-and-effect analysis, standardized work, risk-based cycle counting, and ongoing process monitoring. The literature indicates that record accuracy improves when operational errors are prevented at their source and audits are targeted by item risk rather than applied uniformly. Technology can strengthen visibility, but it cannot replace stable processes, trained employees, and clear ownership. The resulting framework treats inventory accuracy as a controlled retail process outcome rather than a periodic inventory adjustment.

Keywords: Lean Six Sigma, Inventory Record Accuracy, Retail Operations, DMAIC, Cycle Counting

1. Introduction

Retail inventory systems assume that the quantity recorded for each stock-keeping unit and location matches the quantity physically available. This assumption frequently fails. An empirical study of nearly 370,000 records across 37 stores found that 65% were inaccurate, with substantial variation across product categories and stores [1]. Simulation evidence also shows that inventory inaccuracy raises supply-chain cost and out-of-stock levels when physical stock and information-system balances are not aligned [2]. Even small unobserved losses can accumulate into severe replenishment failures because a positive system balance can prevent replenishment orders after physical stock has reached zero [3].

Retail inventory inaccuracy is operational and informational. Shrinkage, misplacement, receiving mistakes, delayed transactions, return errors, and unauthorized adjustments create gaps between book and physical stock. Labor availability and process complexity can sustain these gaps, while transaction errors and unobservable loss affect inventory knowledge through different mechanisms

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[4, 5]. Existing studies isolate error causes, inventory policies, or technologies. A gap remains for an integrated method that guides retailers from defect definition and measurement to root-cause verification, targeted intervention, and sustained control. This paper addresses that gap by mapping evidence on prevention, detection, correction, and control to phase-specific DMAIC outputs.

Lean production provides a system for exposing non-value-adding activity and improving process flow [6]. Lean Six Sigma combines this orientation with disciplined measurement and variation reduction [7]. Integrated Lean Six Sigma is most useful when tool selection follows a defined problem and verified root causes rather than a general cost-reduction program [8, 9]. This paper applies that logic to retail inventory record accuracy through a structured narrative review and a conceptual DMAIC framework. The study examines error mechanisms, measurement requirements, improvement actions, control measures, and implementation limits. Its contribution is a deliberately bounded framework that connects retail execution failures with specific evidence and phase outputs.

2. Research scope and method

The literature search was conducted in August 2026 across INFORMS PubsOnLine, ScienceDirect, Emerald Insight, and Taylor & Francis Online, supplemented by backward citation searching from highly cited inventory-accuracy studies. Search strings combined "inventory record inaccuracy" or "inventory accuracy" with retail, shrinkage, auditing, RFID, anomaly detection, Lean Six Sigma, or DMAIC. Searches were limited to English-language work published from 2002 through 2025.

Records were screened first by title and abstract and then by full-text relevance. Sources were included when they examined retail inventory-record errors or their operational consequences, evaluated detection, correction, or audit approaches, or supplied established Lean and Lean Six Sigma concepts needed to construct the framework. Duplicates, non-scholarly summaries, studies focused only on accounting valuation, and studies without direct relevance to retail execution or process improvement were excluded. The final corpus comprised 12 peer-reviewed journal articles and two foundational books. Evidence was synthesized into three categories: error formation, error detection and correction, and sustained prevention. Findings were then mapped across the five DMAIC phases according to operational relevance, with each phase linked to a specific process output. The method supports a conceptual framework rather than a claim of company-specific causal impact, therefore, no hypothetical pre- and post-project values are presented as empirical results.

3. Inventory record inaccuracy in retail operations

3.1. Definition and operational consequences

Inventory record inaccuracy exists when the system quantity for an item location differs from its physical quantity. A negative inventory discrepancy occurs when physical stock is lower than the recorded quantity, while a positive inventory discrepancy occurs when physical stock exceeds the recorded quantity. The first condition can create phantom inventory: the system reports availability even though the shelf or store has no usable units. The second condition can lead to unnecessary replenishment or incorrect allocation decisions. Both conditions reduce trust in the inventory system and encourage employees to rely on manual checks, informal buffers, or emergency orders.

The effect extends beyond accounting accuracy. Inaccurate records distort reorder timing, demand estimation, promised availability, labor planning, and omnichannel fulfillment. A retail supply-chain simulation found that periodic alignment of physical and system inventory can reduce both cost and out-of-stock performance loss [2]. Analytical work also indicates that stock loss is

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especially damaging in lean systems because lower buffers leave less time for an undetected gap to be corrected before a stockout occurs [3]. Record accuracy is therefore a critical-to-quality characteristic for replenishment and customer service, not only a finance measure.

3.2. Error mechanisms and measurement

Retail record errors enter through several process points. Receiving errors include incorrect units of measure, partial deliveries recorded as complete, and items posted to the wrong location. Misplacement makes inventory physically present but unavailable at the expected shelf or backroom location. Shrinkage and damage reduce physical stock without an equivalent system transaction. Sales, returns, transfers, and adjustments can also be posted late, duplicated, or assigned to the wrong SKU. Research on error causes indicates that backroom and shelf shrinkage can be major drivers, while the availability and composition of labor influence the retailer's ability to maintain accurate records [4].

Measurement must separate error frequency from error magnitude. The percentage of audited SKU locations within an approved tolerance shows conformance, while absolute unit variance and monetary variance show operational and financial severity. Adjustment frequency, repeat-error rate, phantom-inventory incidents, audit hours per corrected record, and stockouts linked to inaccurate balances provide supporting measures. Results should be stratified by store, product category, value, velocity, location, transaction type, and shift. A single average can conceal a small set of high-impact items or processes. Table 1 connects major error mechanisms with observable evidence and business effects.

Table 1. Retail inventory error mechanisms, evidence, and effects [1-5]

Error mechanism	Typical process source	Observable evidence	Primary effect
Unrecorded shrinkage	Theft, damage, spoilage, or disposal without transaction	Physical quantity below system quantity, repeated negative variance	Phantom inventory and delayed replenishment
Misplacement	Incorrect shelf or backroom location	Store-level quantity exists but is unavailable at expected location	Lost sales, search labor, and apparent stockout
Transaction error	Receiving, sale, return, transfer, or adjustment posted incorrectly	Timestamp, SKU, location, or unit-of-measure mismatch	Distorted ordering and allocation
Transaction delay	Physical movement completed before system update	Open transaction or timing gap around the audit	Temporary inaccuracy and misleading baseline

4. DMAIC framework for improving record accuracy

DMAIC converts the accuracy problem into a controlled improvement sequence. Each phase produces evidence required by the next phase, and the Control phase creates feedback for renewed analysis. Figure 1 presents the focused sequence for retail inventory records.

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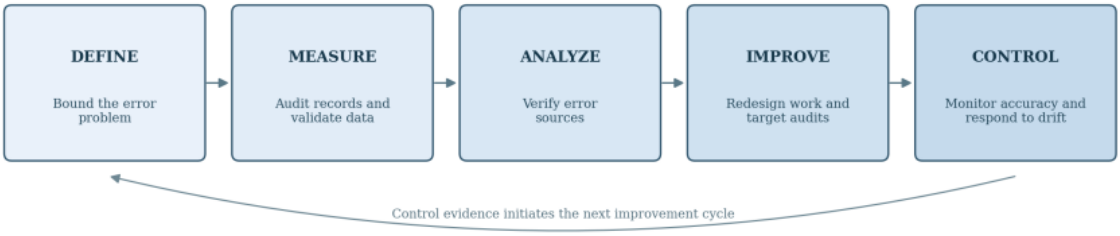


Figure 1. DMAIC control logic for retail inventory record accuracy [7-9]

4.1. Define

The Define phase limits the project to a clear product category, store group, location type, and time period. A suitable problem statement describes the measured gap without assuming its cause, such as a defined frequency of out-of-tolerance records in a selected category combined with repeated phantom-inventory stockouts. The project charter identifies the process owner, affected employees, customer requirements, financial exposure, schedule, and exclusions. Primary critical-to-quality measures include record accuracy, while on-shelf availability and correction lead time serve as supporting performance measures. Guardrail measures include audit labor, service level, and total inventory so that accuracy gains are not purchased through excessive counting or unnecessary stock.

4.2. Measure

The Measure phase establishes a reproducible baseline. Physical counts must be completed by trained counters using a documented freeze or transaction-control rule to prevent timing differences from being mistaken for inventory errors. System snapshots, timestamps, units of measure, storage locations, and open transactions must be preserved so that a timing difference is not misclassified as a true error. A sample should include high-value, high-velocity, promotion-sensitive, shrink-prone, and ordinary items. Blind counts reduce confirmation bias because the counter does not see the recorded quantity before observing the physical quantity. Repeat counts on a subset can test measurement consistency.

The baseline should report the share of records within tolerance, absolute and monetary variance, adjustment frequency, repeat-error rate, and stockouts associated with positive system balances. Transaction extracts should cover receipts, sales, returns, transfers, damages, and manual adjustments. DeHoratius and Raman found that auditing practices can mitigate inaccuracy, which supports treating physical verification as a designed measurement process rather than an annual accounting event [1]. The output of Measure is a validated dataset and a process map linking every inventory movement to its expected system transaction.

4.3. Analyze

The Analyze phase identifies which error types and process steps explain the observed gap. A Pareto chart can rank variance value, error frequency, or stockout impact by SKU, location, transaction type, employee role, or supplier. A cause-and-effect diagram can organize possible causes across categories such as process, people, technology, item, environment, and policy. The 5 Whys can then trace a repeated discrepancy to a controllable source, such as an ambiguous receiving standard, a

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barcode substitution, an unprocessed damage queue, or a location transfer completed physically but not electronically.

Time patterns should also be examined. Run charts or control charts can show whether the error rate is stable, gradually drifting, or affected by promotions, staffing changes, delivery peaks, and system updates. Transaction errors and unobservable loss should not be combined automatically because they change inventory knowledge through different mechanisms [5]. Cross-functional validation is essential. A planner may observe a replenishment failure, while the root cause originates in receiving, shelf replenishment, returns, security, or master data. Only causes supported by audit and process evidence advance to improve.

4.4. Improve

The Improve phase uses prevention and targeted correction. Standardized work should define scanning, quantity verification, unit-of-measure checks, location confirmation, exception labeling, and same-shift transaction completion for receiving, transfers, returns, and damages. Visual location controls and organized storage reduce misplacement and make abnormal inventory easier to detect. These actions reflect Lean's emphasis on visible flow and removal of process ambiguity [10]. Training should connect each transaction to its downstream effect on replenishment rather than presenting accuracy as a separate accounting responsibility.

Correction should be risk-based. High-value, fast-moving, shrink-prone, promotion-sensitive, or high-service items can receive more frequent cycle counts, while stable low-risk items receive less frequent verification. Audit triggers can include a positive record with no recent sales, repeated zero-sales days, unusual adjustment history, or a mismatch between shelf observation and system availability. Research on retail inventory management indicates that audit policies using inventory information can improve inventory control beyond simple zero-balance checks and can prevent replenishment from freezing when records remain positive after physical inventory reaches zero [11].

Technology should address a verified cause. RFID can reduce the effort required to identify misplaced units and improve item-level visibility. Analytical research evaluates RFID as a response to retail misplacement errors [12], while field experiments show that the benefit varies between sales-floor and backroom processes [13]. This variation warns against treating technology as a universal solution. Data-based anomaly detection offers another targeted approach. Recent research using cross-sectional store and SKU data reported substantial cost improvement over incumbent detection methods in its study setting [14]. A pilot should compare accuracy, stockouts, audit labor, transaction compliance, and total inventory before expansion.

4.5. Control

The Control phase assigns ownership and establishes a response plan. A weekly or monthly dashboard can track accuracy within tolerance, absolute variance, monetary variance, repeat-error rate, phantom-inventory stockouts, adjustment frequency, and audit productivity. Control limits or practical thresholds distinguish ordinary fluctuation from a meaningful deterioration. A threshold breach should identify the responsible process owner, required containment, root-cause review, correction date, and verification step.

Process control also requires layered audits of the work that creates records. Supervisors can sample receipts, transfers, returns, and damage transactions for timely and accurate completion. Repeat errors should be reviewed by cause and location rather than cleared through repeated

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adjustments. Master-data changes and new-product introductions need explicit controls because new barcodes, pack sizes, and locations can create fresh failure modes. When a control threshold is breached, the issue should return to the Analyze phase for a renewed root-cause investigation. Table 2 summarizes the evidence, tools, outputs, and control measures associated with each phase.

Table 2. DMAIC phase evidence and outputs for retail inventory accuracy [7-14]

Phase	Primary focus	Core evidence and tools	Required output
Define	Bound the accuracy gap and customer effect	Project charter, scope, CTQs, guardrail measures	Approved problem statement and ownership
Measure	Create a trustworthy baseline	Blind counts, system snapshots, process map, stratification	Validated audit dataset and operational definitions
Analyze	Verify error sources and patterns	Pareto chart, cause-and-effect diagram, 5 Whys, time analysis	Evidence-supported root causes
Improve	Prevent errors and target correction	Standardized work, visual controls, risk-based counts, pilot	Tested improvement process and audit design
Control	Detect drift and sustain responsibility	Dashboard, thresholds, layered audit, response plan	Control plan with escalation and review schedule

5. Implementation conditions and limitations

5.1. Implementation conditions

The framework depends on employee participation, management support, process ownership, and data governance. Store employees hold detailed knowledge of shortcuts, congestion, mislabeled locations, and exception queues, so their involvement can improve cause identification and the design of practical standard work. Management should allocate sufficient time and resources for audits and correction, align incentives with record quality, and avoid emphasizing speed or labor reduction in ways that increase unrecorded work. Lean Six Sigma governance should connect the project to customer availability and financial performance rather than treating accuracy as an isolated percentage [8, 9].

Technology investment should follow the same evidence-based logic. RFID, computer vision, and anomaly detection can reduce search and detection effort, but they cannot compensate for poor master data or weak transaction compliance. This improvement portfolio should therefore begin with stable process rules and introduce technology where the verified error pattern justifies its cost. Audit resources should be concentrated where the expected service or financial loss is greatest.

5.2. Limitations and future research

This study is conceptual and does not estimate the effect of DMAIC using primary company data. Retail formats differ in product variety, shrink exposure, labor design, shelf structure, and technology, so a single tolerance level or counting frequency cannot be appropriate for all operations. The reviewed evidence also uses different definitions of accuracy and different analytical settings. Future research should apply the framework to a bounded store category, report pre- and post-pilot performance with a comparison group when possible, and examine whether improvements

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remain after the project team withdraws. Future research can also examine how targeted audits and automated detection can be combined across product risk classes.

6. Conclusion

Inventory record inaccuracy is a consequential retail process defect that separates system records from physically available stock. It can delay replenishment, create phantom inventory, reduce on-shelf availability, increase operating costs, and weaken customer service.

Lean Six Sigma offers a focused approach to this problem. Lean addresses process ambiguity, delays, misplacement, and weak flow, while Six Sigma emphasizes measurement and variation reduction. DMAIC organizes improvement into a repeatable sequence: Define limits the problem and its customer impact, Measure creates a reliable physical and system baseline, Analyze identifies error sources, Improve combines source prevention with risk-based auditing and targeted technology, and Control maintains ownership, monitoring, and response rules.

An effective improvement strategy does not rely on counting alone. Repeated corrections can consume labor without preventing the same errors from recurring. Effective control combines standardized transactions, trained employees, visible locations, risk-based cycle counts, exception detection, and timely root-cause response. RFID and analytical tools cannot replace stable processes. The proposed framework therefore treats inventory record accuracy as an operational capability supporting replenishment and customer service. Its bounded scope also provides a basis for future retail pilots using auditable pre- and post-improvement measures. Because the study is conceptual, the framework should be validated through bounded store-level pilots. Future applications should report accuracy, stockouts, audit labor, and total inventory before and after implementation, preferably with a comparison group, and should test whether gains persist after project support ends. This evidence would distinguish sustainable process improvement from temporary correction and clarify which combinations of standard work, targeted counts, RFID, and analytics are most effective across retail formats.

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