INTEGRATED FUEL STATION AUTOMATION

The Impact of Integrated Fuel Station Automation on Financial Control in Saudi Arabia

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Abstract

Fuel station automation extends beyond balancing cash drawers and card settlements. A complete control design links dispenser records, automated tank gauging, physical fuel deliveries, fleet authorisations, customer receivables, electronic invoices and the general ledger. This review examines Saudi station reconciliation mechanisms and presents a hypothetical cash workflow in which active review time declines from 68 to 33 minutes per 1,000 transactions; the result is not a measured Saudi efficiency gain. It then sets out practical controls for wet-stock variance, fleet credit and tax-document exceptions. The recommendations prioritise reliable transaction identifiers, independent evidence, defined exception ownership, safe offline recovery and a multi-site pilot. An investment case should recognise only demonstrated cash savings and confirmed loss prevention after integration, hardware, training and maintenance costs.

Keywords: fuel station automation; cash reconciliation; payment settlement; internal control; Saudi Arabia

1 Introduction

A busy fuel station generates several records for one sale. The dispenser records fuel dispensed. The point of sale records products, tax, and method of payment. The drawer holds cash, or a payment processor records a card transaction. Finance posts revenue and ultimately sees a bank deposit. Each record answers a different question. A balanced drawer gives evidence about cash handed over during a shift. A completed card receipt gives evidence of payment at the point of sale, while the bank statement supplies evidence that the proceeds reached the merchant. An automated system can reconcile these stages, provided it keeps the identity and timing of each event.

Saudi Arabia's national retail payment figures show the broader context. Electronic payments accounted for 70% of retail payments by volume in 2023, 79% in 2024, and 85% in 2025. Those figures describe retail transactions nationally. They provide no estimate of the cash share for a particular fuel retailer or station. A highway forecourt, an urban site, and a station serving commercial fleets can have different mixes. At a site where cash declines, physical counting may take less time even without new software. Meanwhile, card refunds, settlement batches, and provider fees may occupy a greater share of the finance team's attention. The migration therefore changes which records need reconciliation. Sources: Saudi Central Bank announcements for 2023, 2024 and 2025.

Saudi e invoicing further increases the importance of consistent transaction records. A valid invoice or credit note can support the audit trail and help explain a difference between original sales and later adjustments. Tax document generation and integration follow the applicable requirements for the taxpayer and invoice type. Compliance evidence still needs to be paired with independent information about tender, physical custody, or settlement. This study treats the electronic invoice,

accounting event, and payment event as related evidence streams. It addresses reconciliation as an operating control in its own right. See ZATCA's e-invoicing detailed guideline and integration-phase guidance; obligations differ by invoice type and taxpayer rollout wave.

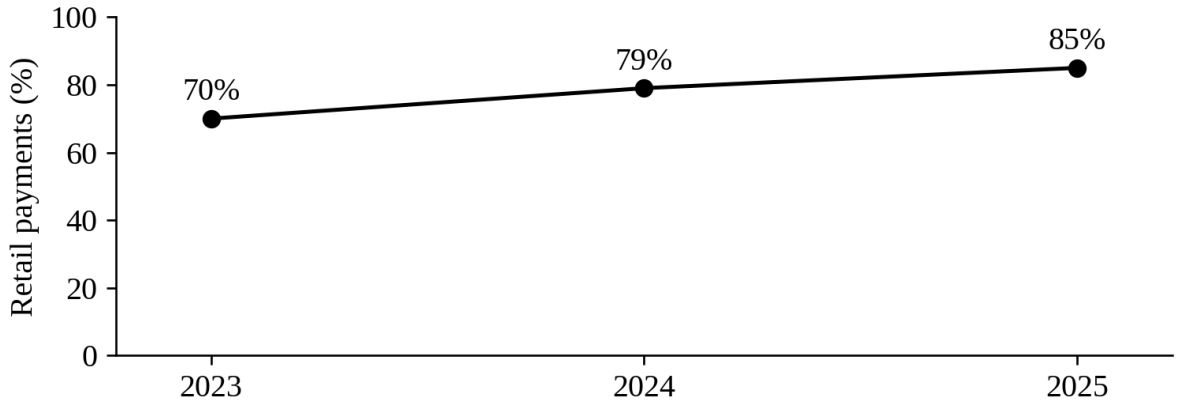


Figure 1. Electronic share of Saudi retail payments by transaction volume. National figures from the Saudi Central Bank.

2 Aim and research questions

The aim is to explain how fuel station automation affects the timing, accuracy, and workload of daily reconciliation in Saudi Arabia. The primary measures are active staff minutes needed for a comparable transaction load and the age of unresolved discrepancies. Secondary measures include confirmed cash loss, unmatched settlement amounts, and the completeness of source data. Physical cash includes only drawer activity, cash transfers, and deposits. A broader receipts reconciliation connects digital tenders and other receivables to settlement or collection. Defining these boundaries prevents a delayed card settlement from being reported as a cash shortage.

The first research question asks which sources and identifiers an automated station needs to reconcile receipts from the dispenser through to the general ledger. The second asks how a reduction in manually reviewed transactions changes workload and what conditions might offset that benefit. The third asks how operators can distinguish effects of automation from changes in payment mix, transaction volume, and organisational practice. The analysis uses both accounting and operational outcomes because a faster close has limited value if the station has fewer records available for review or passes discrepancies to a later reporting period.

3 Research methodology

3.1 Evidence selection

The paper uses a narrative review of Saudi payment publications and electronic invoicing guidance, international fuel retail interface standards, payment security resources, internal control frameworks, and evaluation methods. Saudi publications establish payment and tax record context. Forecourt standards identify interfaces among dispensers, point of sale software, and payment systems. Security and control sources inform access, evidence, supervision, and exception handling. Evaluation studies inform the design of a station level pilot. The bibliography includes public policy, technical standards, and research because each source type answers a different part of the question.

The paper does not use private station records or estimate effects observed across Saudi stations. It includes a model to make the mechanism and assumptions testable. The model fixes transaction volume and average review time, then varies manual review rates and fixed closing work. Graphs distinguish national payment statistics from hypothetical workload outcomes. A proposed field design sets out how to estimate effects after a rollout. Separating these components allows the reader to use the numerical example to test a business case without mistaking it for evidence of realised savings.

3.2 Definition of automation

The intervention has four components. First, the forecourt controller sends dispensing events to the point of sale or the back office through a monitored interface. Second, tender and reversal records are linked to the relevant sale. Third, acquirer and bank records are brought into the accounting workflow together with cash count and deposit evidence. Fourth, matching rules close straightforward items and assign exceptions for investigation. An electronic cash count form on its own improves record legibility but supplies only one component. A fair evaluation must document the installation dates and availability of each component at every station.

The analytical unit is the station day, supported by shift level records and transaction detail. A shift may split a trading day and a card settlement can follow a different cut off time. Cash transfers should be traceable across those boundaries. A day has completed reconciliation when expected inputs have arrived, required checks have run, and unresolved items have an assigned status and owner. Recording a shift close time separately from end to end settlement prevents processor timing from obscuring improvements in staff productivity. An invoice timestamp, accounting business date, bank value date, and time of actual cash count each serve different purposes.

3.3 Broader operating and control architecture

An integrated station platform joins dispenser transactions and payment reconciliation with automated tank gauging (ATG), calibrated tank tables, delivery records, inventory movements, fleet authorisations, customer credit, electronic invoices and enterprise resource planning (ERP). These functions should be evaluated as separate but connected control streams. Cash matching can reduce unexplained tender balances without identifying physical fuel loss. Similarly, a valid card settlement does not prove a delivery was complete or a fleet invoice collectible.

Wet-stock reconciliation uses the identity: expected closing litres = opening measured litres + verified deliveries − metered sales ± authorised adjustments. Expected litres are compared with calibrated, temperature-consistent ATG readings by tank and grade. Discrepancies may arise from delivery shortfalls, dispenser meter calibration, water ingress, leakage, temperature effects, recording delays or measurement error. A variance alert triggers an investigation; it does not itself establish theft or recovered stock. The system should preserve tank readings, delivery timestamps, meter totals, calibration versions and approval histories so a reviewer can reproduce every adjustment.

Fleet control begins before dispensing: the operator validates the customer contract, vehicle or driver identity, product entitlement, approved price, per-transaction and period limits, credit availability and any blocked-account status. Prepaid transactions, postpaid receivables and third-party platform settlements must enter different clearing or receivable accounts. Postpaid transactions then feed consolidated customer invoices, contractual discounts, credit notes, statements, disputes, ageing and collection activity. The station should reconcile approved litres and contracted prices to both invoice

lines and ERP customer balances; fleet receivables must never be grouped automatically with card-acquirer cash in transit.

E-invoicing integration requires an invoice status record alongside the commercial sale, including document identifier, applicable reporting or clearance response, retry status and tax posting. Detailed technical design must be checked against the ZATCA requirements applicable to the taxpayer and invoice type. Offline operations require safeguarded local sequencing, authorised transaction limits, tamper-evident queued events and controlled replay when connectivity returns. The architecture must prevent duplicated delivery, sale, fleet invoice or tax-document postings during replay.

4 Reconciliation workflow

4.1 From dispenser to payment

Fuel dispensing has operational stages that can include an authorisation, the delivery of fuel, completion of the sale, and a receipt. A preauthorisation secures permission to take up to a specified amount. The final captured amount may be lower after the customer stops dispensing. An automation rule should use the completed charge and preserve the link to the initial event. Matching the preauthorised amount against bank settlement could produce a false shortage. The forecourt controller should identify site, pump, dispenser sequence, and timing. The point of sale should retain the sale identifier and any trigger for a reversal or reissue.

Fuel volumes can provide a completeness check. When a dispenser records a completed fuel delivery that has no corresponding sale, the difference warrants investigation. Maintenance dispenses, equipment tests, and data feed gaps are possible explanations. Fuel meter totals and recorded sales serve different purposes and are not directly interchangeable unless the records use consistent measurement, pricing, grade, and date boundaries. A store basket paid together with fuel will carry additional revenue and tax fields. A split tender adds more than one payment record to a single sale. Controls should aggregate verified payment components before testing the amount due, and avoid posting the same invoiced value twice.

Standalone terminals and offline operation can break the automated link. In those cases, a reliable terminal reference, merchant identifier, amount, and time window can narrow candidate matches. Two consecutive customers can pay the same amount at the same station. An amount and date match can therefore make the queue look smaller while allocating the wrong payment. A unique shared identifier should take precedence. If several credible combinations remain, the system should display the candidate records and request supporting evidence. Replay after an outage must be safe to run twice without duplicating a sale or ledger entry.

4.2 Physical custody and deposits

Expected closing drawer cash starts with the recorded float. Add cash receipts and documented cash transfers in. Deduct cash refunds, approved payouts, and drops or transfers out. Compare the resulting expected cash with a signed physical count before removing the amount due for handover, or adjust the calculation consistently when the count happens after the handover. A cash refund reduces drawer inventory while a refund paid to a card changes settlement. Counting proof is stronger when it records who prepared the count, who reviewed discrepancies, and when those steps occurred.

A sealed bag transfer changes the location and accountable holder of cash. The bag reference and custody log establish a link from the drawer or safe to collection. A collected bag and its expected amount provide a separate record to match against the banking deposit. If a refund was omitted from the register, a daily drawer difference may appear even when the deposit equals the counted cash. If the drawer balances but the bank credits less than the bag total, the discrepancy arises later and belongs to the deposit investigation. Separating these paths gives each difference an owner and keeps a single event from being counted twice.

Cash found in excess can indicate a sale entered as card although it was paid in cash, an incorrect float, or change withheld by mistake. Netting an excess at one till against a shortage at another can remove evidence of both events. Managers should see absolute differences, signed differences, and aged exceptions by site and shift. A small adjustment can have low value individually and still reveal a persistent process problem. Repeated tiny discrepancies around a terminal change or a particular shift transition justify a review of configuration and practice. Materiality should guide the depth of investigation while every difference remains recorded.

4.3 Digital receipts and the ledger

For card payments, matching proceeds through captured transactions, batch settlement, and bank receipt. Batches may combine multiple terminals or arrive after weekends and cut offs. Acquirer deductions can include contracted fees, refunds, or chargebacks under the applicable agreement. To compare with the bank, finance must bridge from captured gross amounts to expected net proceeds. Chargebacks should retain a link to the original purchase and be aged from the point at which the merchant can act. Fleet accounts can produce a receivable collected later and should have separate ageing. If the operator treats a fleet invoice as a current drawer or bank item, the process will report false differences.

A payout may bundle several settlement days, while a partial payment can leave an open balance. Rules should support one to many and many to one matching with totals verified at each stage. A declared terminal mapping is necessary when devices move between stations or change merchant accounts. Asset registers should retain effective dates so the system uses the correct mapping for older transactions. The ledger can hold clearing accounts for individual payment streams until settlement. Those balances need periodic tie out to open items and provider records. An automated accounting entry completes one stage of the workflow, while unresolved balances require their own monitoring.

Table 1. Evidence needed at each reconciliation stage.

Stage	Primary evidence	Independent check
Dispensing	Controller event, site, pump, sequence	Completed sale or authorised test
Cash drawer	Float, cash sale, refund, payout, and transfer log	Signed physical count
Cash deposit	Safe log, bag ID, and handover record	Bank deposit and value date
Card settlement	Capture ID and acquirer batch breakdown	Bank credit and documented deductions
Ledger close	Tender clearing balance and journals	Open item schedule and approved adjustments

5 Scenario analysis

5.1 Changes in staff workload

The example compares processing for 1,000 transactions. The baseline assumes 28 minutes of fixed close tasks and a 2.0% manual review rate. Each flagged item takes an average of two minutes to resolve or document for follow up. Expected total active time is 68 minutes. The integrated scenario assumes 21 minutes of fixed work and a 0.6% review rate, yielding 33 minutes. The 35 minute difference combines seven minutes in routine tasks with 28 minutes from reviewing fewer items. The modeled time reduction is 51.5% relative to baseline. It depends on the assumed review rates, the scope of fixed work, and the effort to work an exception.

A third scenario tests a degraded environment such as a missing settlement feed or recurring terminal mapping errors. It assumes 25 minutes of fixed work and a 2.5% review rate. Expected labour rises to 75 minutes. The comparison shows why an installation date alone tells little about service quality. A network could capture the number of feed outages and hours at risk to estimate how often it operates in each state. The scenarios express active labour and do not reflect elapsed time while waiting for a bank or provider. That waiting time should be measured separately because an integration can save work without accelerating cash availability.

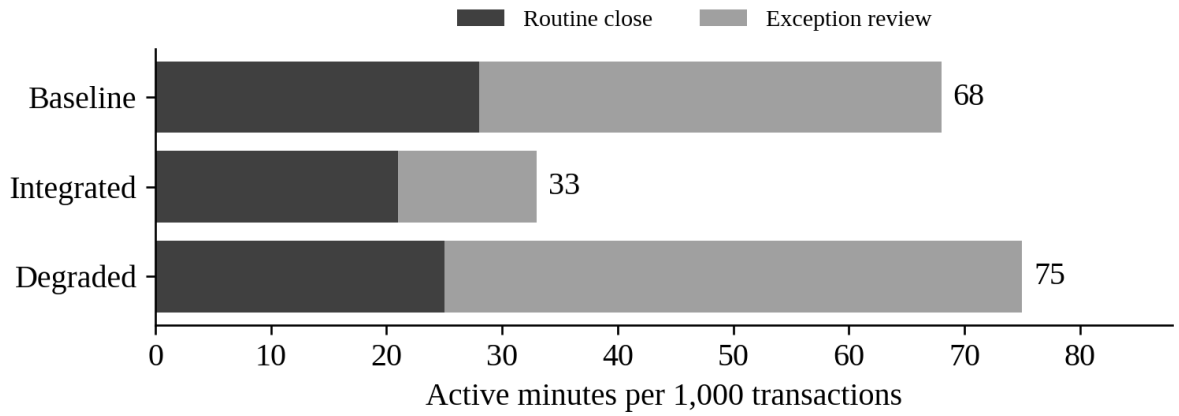


Figure 2. Reconciliation workload under three illustrative scenarios.

The assumed two minutes are a weighted average across cases. A late file may be resolved by one review that clears a batch. Ambiguous references or disputed chargebacks may take much longer and involve several staff members. If the integrated case produces six disputes that each take six minutes to investigate, closing work increases to 57 minutes. The baseline and improved scenarios should use measured time by exception type when station data becomes available. Operators should track the median alongside upper percentiles so a reduction in common tasks is visible even when rare incidents still dominate workload at month end.

5.2 Financial interpretation

A station closing once a day at the modeled workload would save 17.5 active staff hours in a 30 day month in the integrated case. At an illustrative loaded cost of SAR 45 per hour, the time is worth about SAR 788 per month. The saving becomes a cash benefit only to the extent it avoids paid overtime, changes the staffing requirement, or replaces purchased services. If the same staff remain

on shift, the time can be redeployed to other work without lowering the wage bill. The investment case should account for licence fees, interfaces, monitoring, training, connectivity, support, and periodic testing. Time released and actual cash savings should be shown separately.

A claimed reduction in leakage needs evidence of genuine losses under both workflows. Confirmed loss should follow investigation and exclude legitimate fees, timed settlement differences, and already recovered amounts. More complete source data may initially raise observed discrepancies because existing errors become visible. A temporary increase in the queue can be consistent with better detection. Conversely, a sudden drop in exceptions can result from a missing feed or loose tolerance. Reports should show transaction completeness alongside queue size and test samples of automatically matched items to estimate the share of false matches. Reducing the queue is valuable when the evidence demonstrates the quality of the remaining matches.

5.3 Worked examples for inventory and fleet credit

Illustrative wet-stock test: a tank starts with 20,000 litres, receives a verified 8,000-litre delivery and dispenses 6,500 metered litres. Expected closing stock is 21,500 litres. If the appropriately calibrated ATG reading is 21,420 litres, the preliminary discrepancy is −80 litres, or about 1.23% of dispensed volume. A supervisor should first test measurement timing, temperature and approved transfers, then inspect the delivery and pump logs. The number is a hypothetical training example, not an observed Saudi loss rate; only a resolved and substantiated discrepancy may enter a claim of financial savings.

Illustrative postpaid fleet test: an authorised vehicle receives 200 litres at an agreed SAR 2.00 per litre before any applicable tax treatment, generating SAR 400 of contractual sales. The transaction carries a customer identifier, vehicle ID, approved price and invoice reference. When the customer is invoiced on agreed 30-day terms, SAR 400 is recorded as the customer receivable rather than a bank card settlement. A remittance of SAR 400 clears the receivable only when identified and posted. A late payment stays in the ageing report and is escalated under the approved credit policy. These values demonstrate the control chain, not a claim about actual local fuel tariffs.

6 Controls and implementation

6.1 Exception triage and ownership

Table 2. Exception categories and first actions.

Exception	Initial owner	First action
Unmatched completed delivery	Station operations	Check pump log and point of sale sequence.
Drawer shortage	Site supervisor	Recount and trace transfers, refunds, and float.
Deposit shortage	Treasury	Compare bag evidence with collection and bank records.
Late card settlement	Finance operations	Check expected settlement and provider status.
Missing or duplicate feed	Technology support	Check sequence totals and validate replay.

A standard queue gives priority to high value items, missing records, old unresolved cash transfers, and exceptions that recur across terminals. Staff should be able to distinguish a payment that is within its normal settlement window from one that has exceeded it. Aging should use an expected

date based on observed settlement terms and relevant calendars. A disputed amount can remain open with a scheduled action and a named owner. Reopening a previously matched item should preserve the original decision and the reason for revision. Where a rule or mapping is corrected centrally, affected stations should be able to reprocess the relevant period and compare the prior and revised outcomes.

Segregation of duties is important because reconciliations influence whether a shortage is investigated or written off. A person who collects cash or posts a refund should have limited authority to approve related adjustments. At a small station where staffing limits separation, a regional finance reviewer can perform independent checks with access to source files and shift evidence. Settlement feeds should use restricted credentials, and exception reviews should display only the payment information necessary for resolution. Documenting the source and timing of changes to matching rules allows finance to reproduce results after an interface update. Limits, approvals, and error logs belong in the control design and should be tested before launch.

6.2 Continuity and verification

Monitoring must check whether each expected interface file and terminal sequence arrived. Compare independent totals at the boundaries between the forecourt controller, point of sale, payment provider, and ledger. A scheduled file that arrives empty should be investigated against expected trading and outage records. Connectivity problems require a documented fallback for stores operating offline. After service returns, reimport records using an identifier that prevents duplicate posting. Verify duplicate detection and accounting reversals in testing, using realistic sequences for partial fills, retries, stacked refunds, and transfers across a shift change. This work reduces the risk that an automated close confirms a balance based on an incomplete day.

Comparable workforce instructions matter across the network. Cashiers need to know when to record the cash transfer and how to document a terminal outage. Site managers need clear authority to pause an automatic posting where source data is incomplete. Central finance can own bank and acquirer reconciliation rules while station managers handle custody evidence and local exceptions. Technology support can own availability and root cause analysis for faulty interfaces. In a mature process, independent assurance can sample approved overrides and evidence underlying reported closure. A vendor can supply a matching service while the operator remains responsible for financial controls and investigations.

6.3 Worked example of a shift close

Consider a station with a SAR 500 opening float, SAR 3,200 of cash sales, SAR 50 of cash refunds, and SAR 2,500 transferred to the safe. Its expected drawer cash is SAR 1,150. A signed count of SAR 1,130 creates a shortage of SAR 20 pending investigation. The safe transfer remains an expected deposit of SAR 2,500 if no other receipts are assigned to the bag. If the credited amount is SAR 2,500, there is no bag discrepancy. Reporting the SAR 20 at both stages would double count the same potential loss.

Assume the same shift captures SAR 12,000 of card payments and processes SAR 100 of card refunds. An acquirer deduction of SAR 60 produces an expected net settlement of SAR 11,840 for those items. A first bank credit of SAR 11,500 leaves SAR 340 open. If the acquirer confirms a separate credit within the contractual window, the remaining amount stays open as a timing item until that credit arrives. It is reported as overdue only when the applicable settlement window expires. The SAR 340

has a different control owner from the SAR 20 cash difference, and neither should be netted against the other.

Recording both examples on a single shift report helps supervisors see what can validly close. The cashier can reconcile the physical count and explain discrepancies in the shift record. The treasury or finance reviewer can verify that the deposit arrives and card batches clear. An open item may persist in a central queue even though the station shift is closed. The system should retain a timestamp for each milestone. At month end the ledger clearing balance can then be explained by a list of identifiable items, with dates, expected receipts, and evidence for adjustments. This trace is more informative than a status flag alone.

6.4 Matching precision and audit samples

The share of records with unique transaction identifiers should be measured before deciding which matches can be automated. Some terminals send only a reference that repeats after a reset or across devices. Matching keys should therefore include the relevant merchant or terminal identifier, and a sequence scope where references can recur. A limited amount tolerance can handle documented rounding or conversion differences. The basis for the tolerance should be specified by tender and adjustment type. Combining many individually tolerated differences can conceal a material aggregate variance, so finance should review the total value accepted under tolerance rules each period.

A sample of automatically closed items can be traced back to the original sale, provider record, and bank receipt. Sampling should include lower value payments and cases with repeated amounts, split tenders, refunds, and offline uploads. A sample restricted to exact amount matches with strong identifiers is unlikely to reveal weak logic used elsewhere. Random selection within relevant groups helps estimate error rates, while targeted investigation of high value or unusual transactions identifies classes of control failure. A rejected match should record the reason and the eventual corrected allocation. Comparing the sample before and after a rule change can show whether a smaller queue reflects improved data or wider automatic closure.

If the platform classifies several bank receipts under one settlement number, tests should show that the aggregated amount equals the expected value and that each receipt is used once. The converse also applies when one credit combines several provider batches. Analysts should retain the set of component identifiers and the version of the rule that joined them. Small rounding adjustments need a ledger treatment consistent with their cause. When unmatched records remain open at reporting cut off, a separate reconciliation report can bridge the general ledger balance to provider and bank evidence. The bridge should contain known timing differences as well as exceptions requiring a decision.

6.5 Measuring service performance during rollout

One performance measure should record whether every required source was present when reconciliation ran. A second should record whether the same operator could reproduce the result from preserved records. Together they distinguish a fast process from one that closes without complete evidence. Sites can document the share of trading days reconciled with complete feeds, exceptions reopened after audit checks, and unresolved balances by age. A dashboard should retain missing days in the denominator. Excluding them rewards the site for gaps in evidence and hides the cost of recovery.

Some locations may have to rely on temporary logs during an outage. A fallback log can track the source system, shift, expected transaction range, amount totals, and person responsible for later import. When normal service resumes, the finance team can compare the imported transactions with those totals. If money has already been counted or deposited, actual custody events should stay tied to their original times. The restored data can be posted with the proper business date, and subsequent corrections should leave a trace. A simulated outage in a pilot can measure recovery time and reveal unclear responsibilities before the process is adopted across the network.

Managers should include different payment providers and operating conditions in pilot testing. A site using only one terminal and a single daily bank deposit offers a useful baseline, but it exercises few of the conditions that cause breaks at larger stations. A representative test includes several tills, a fleet receivable, mixed tender sales, and refunds posted after the shift closes. Treasury should check how the provider documents rejected settlement and how long finance has to challenge a deduction. A trial can establish which exceptions are safely resolved at the site and which require central access to bank records.

6.6 Actionable implementation recommendations

Implement the programme in three linked workstreams. First, establish a verified baseline across station cash close, tank/day and grade/day stock variance, fuel delivery shortages, fleet account sales, aged receivables, invoice rejection and reconciliation labour. Use comparable periods and reconcile the measures to source records. Second, pilot interoperable ATG, dispenser-controller, POS, fleet, ERP and ZATCA interfaces at sites deliberately chosen for different tank configurations, fleet volume, tender mix and connectivity. Third, expand only after control completeness, resilience and whole-life costs are independently tested.

Assign explicit exception owners. The site supervisor handles cash-drawer mismatches and missing pump events; wet-stock operations investigates tank, delivery and dispenser variance and escalates suspected leakage immediately under the site safety procedure; credit control owns fleet limits, overdue invoices and customer disputes; tax compliance owns invoice rejection; finance approves ledger corrections; IT owns feed gaps, duplicate messages and controlled replay. Define severity thresholds from the operator's risk appetite, not arbitrary universal tolerances. Separate staff who receive fuel from those authorising stock write-offs, and separate fleet account setup from credit-limit overrides and invoice corrections. Retain a searchable, immutable audit trail of user, timestamp, previous value, reason and approval.

Review a weekly dashboard showing wet-stock variance in litres and as a share of metered sales, reconciled delivery shortfalls, confirmed loss and recovery in SAR, percentage of authorised fleet transactions correctly invoiced, days sales outstanding, overdue receivables, rejected or pending electronic invoices, feed uptime, manual adjustments and reconciliation cost per 1,000 transactions. For investment appraisal include ATG hardware and calibration, connectivity, integration, licences, cyber controls, implementation disruption, training, maintenance and future replacement. Credit benefits only when evidenced: time released is a productivity benefit until paid hours or other expenditure actually fall; detected stock anomalies are not savings until losses are prevented or recovered; faster invoicing is not cash generation unless collections improve.

7 Field evaluation and implications

Start with a preinstallation baseline from comparable stations, recording traffic, tender mix, staff scheduling, number of tills, settlement procedures, and uptime. Use planned installations at different dates to compare treated stations with sites that are still using the baseline process. A parallel run can test the match rules and quantify false matches before automated journals are trusted. During this period both methods can process a sample of the same transactions. Over time, estimate changes by installation cohort, test whether trends already diverged before installation, and report uncertainty at the level of the station. When a comparable network is unavailable, a sufficiently long interrupted time series can help estimate level and trend changes, with qualifications for events occurring at the same time.

Track active minutes, elapsed time to the shift close, age at ultimate settlement, overdue exception value, and confirmed cash variance per SAR of cash receipts. Normalisation matters because the share of card payments can change independently of the intervention. A well designed analysis can show time per 1,000 total transactions alongside cash loss per SAR 10,000 of cash receipts and card exceptions per 1,000 captures. Use a consistent definition of a flagged item so a change in bundling does not mechanically change the queue. Include outage days, temporary staffing, holidays, and unusually high sales volumes. Results from a selective set of stable days would overstate operational reliability.

The rollout design should identify concurrent changes. Switching acquirers can improve settlement references while bringing different timing and fees. Extending opening hours can add shift boundaries. Replacing a station manager can change the quality of counting and documentation. If all these changes occur with a technology upgrade, the measured improvement reflects the package. Operators can stagger particular changes or analyse sites with comparable exposure. Outcomes should also be compared across high and low volume stations. A high volume site can save more time in absolute terms, while a site with unreliable connectivity can face higher failure costs. A decision about expansion should use both results.

Saudi Arabia's digital payments transition increases the relevance of consistent integration and reliable bank evidence. Fuel retailers can use stable transaction keys and documented mappings to bring newer payment types into the same governance model. Central finance can compare performance and enforce a common close standard without assuming every station uses the same tender mix. Technology procurement should specify complete exports, replay capability, support for settlement breakdowns, and traceable changes. Successful implementation can free managers to investigate genuine anomalies earlier while retaining evidence of what happened during the shift.

A handover plan should identify the person who checks that a missing feed is restored, the person who validates the resulting accounting entries, and the reviewer who signs off on any remaining discrepancies. An issue may affect several sites at once if it originates with a single provider. A central incident record can explain the shared cause while leaving each site's financial difference in the appropriate ledger. This supports consistent reporting and helps ensure that recovery work is documented thoroughly for later review.

8 Limitations and future research

The workload figures are illustrative. No Saudi fuel station sample was used to estimate time savings, cash loss, or settlement delays. Retail payment percentages are national context and cannot calibrate

station level tender shares. Results depend on the starting quality of the records, the average effort for different exceptions, and the extent to which a retailer integrates its bank and payment providers. The analysis does not model the cost of a major outage, the full expense of systems deployment, or the probability that a match conceals a real error. Those gaps are material when choosing a vendor or making a large investment.

Future work can use anonymised event and settlement records to study how often discrepancies arise from missing feeds, cash custody, or provider timing. It can estimate how match accuracy differs across payments and settlement providers. Researchers could compare rules that prioritise unique references with more complex methods for candidate matching, measuring both false matches and missed pairings. A separate study could compare financial returns across network sizes and starting levels of automation. Research on the timing and quality of data recovery following a station outage would help determine which controls should be tested most often.

9 Conclusion

Automation can improve Saudi fuel station controls when it links payment, wet-stock, fleet credit, electronic invoicing and accounting records while preserving an independently testable audit trail. The illustrative decline from 68 to 33 staff minutes per 1,000 transactions concerns cash reconciliation alone; it cannot establish financial returns or loss reduction for a complete station system. Before wider deployment, operators should measure tank and delivery discrepancies, authorised fleet sales, overdue receivables, tax-document rejection, settlement completeness and recovery after outages, alongside staff time. A multi-site pilot should distinguish suspected exceptions from verified losses, faster processes from realised cash savings and software benefits from simultaneous operational changes. The practical recommendation is a staged, interoperable control programme with named owners, explicit escalation, full lifecycle costs and measurable rollout gates.

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