ISBN: 978-628-96613-3-0. ISSN: 2414-6390. Digital Object Identifier: https://dx.doi.org/10.18687/LACCEI2026.1.1.221

Supply Management and Lean Logistics to Increase Internal Service Level in a Fermented Beverage Microenterprise: A Case Study with Discrete-Event Simulation

Jorge Vergiu[1], Fabricio Gamero[2], Cintia Rojas[3], Rosmery Arango[4], Carla Castilla[5] and Evelin Santos[6]

[123456] *Universidad ESAN, Perú,* jvergiu@esan.edu.pe, 21100090@ue.edu.pe, 20200088@ue.edu.pe, 21101174@ue.edu.pe, 19100252@ue.edu.pe, 21101211@ue.edu.pe

Abstract- This paper examines how supply management, framed in lean logistics, can improve internal service level in a microenterprise producing artisanal fermented beverages. Using a mixed-method case study (documents, observation, interviews, demand analysis, and discrete-event simulation), the intervention integrates a lightweight S&OP cadence, pragmatic MRP configuration, standardized purchasing/receiving/dispatch routines, and competency-based training. Case evidence indicates fewer expedite purchases and coordination losses, investment recovery below 18 months, and an annual ROI close to 517%. The contribution is a replicable operating model that links supply decisions, process stability, and internal service performance under demand volatility and seasonal inputs.

keywords-- supply management; internal service level; lean logistics; S&OP; MRP; discrete-event simulation; artisanal beverages

I. INTRODUCTION

Artisanal fermented beverage microenterprises often grow commercially faster than they mature operationally. Demand volatility, seasonal inputs, and working-capital constraints frequently push the system into "reaction mode": urgent purchases, last-minute rescheduling, mix changes, and coordination losses across sales, purchasing, production, and dispatch. In these settings, internal service level—treating production and dispatch as "customers" of the supply process—is not ancillary; it determines flow continuity and ultimately external fulfillment.

Logistics scholarship emphasizes that sustainable advantage is built on reliability and coordination rather than isolated cost minimization [1]. Supply chain management highlights the need to align strategy, planning, and execution so uncertainty becomes operable decisions [2]. From a lean perspective, the core issue is not inventory per se, but variability and waste accumulated when flow breaks: waiting, motion, rework, and expedites that degrade service and increase total cost [3]. Experience from lean transformations shows that sustaining improvement requires management routines and learning loops, not just tools [4].

In purchasing, classical evidence indicates that sourcing must become strategic risk-and-value management, segmenting categories by profit impact and supplier-market complexity [5]. This is especially critical in microenterprises because managerial time is scarce; without focus, resources disperse into administrative tasks while critical items (e.g., seasonal perishables) remain unmanaged. Modern supply management emphasizes supplier selection, performance measurement, capability development, and contract governance rather than unit-price negotiation alone [6].

Methodologically, when a process exhibits queues, shared resources, and high variability, discrete-event simulation supports system-level evaluation without disrupting operations, capturing non-linear effects that deterministic analyses often miss [7], [8]. In the case analyzed—a Peruvian microenterprise producing fermented beverages—the operational delivery window is 24–48 hours, and seasonal inputs exhibit high variability; for fruit inputs, the case reports an average procurement delay of 2.67 days relative to the standard time, generating production waiting and expedite purchasing [9].

Accordingly, this paper asks: how can a redesign of supply management, supported by lean logistics and integrated planning, improve internal service level in an artisanal fermented beverage company? The contribution is (i) a replicable intervention architecture (S&OP + MRP + standardization + capability building) and (ii) an empirically grounded articulation between supply decisions, process stability, and internal service performance.

II. CONCEPTUAL BACKGROUND

A. Internal service level as a performance variable

Internal service level is defined here as the probability that the supply process enables the production and dispatch plan without material shortages, with accuracy and within the required time. Operationally, it can be expressed through indicators such as material availability at batch start, internal delivery compliance, internal picking accuracy, and weekly plan stability.

Logistics literature suggests performance should be evaluated by total cost and reliability. A lower-priced purchase that arrives late can be more expensive if it breaks flow, triggers overtime and causes lost sales [1]. Cross-functional coordination is the mechanism that translates forecasts and orders into coherent capacity, inventory, and purchasing decisions [2], [10].

B. Lean logistics and variability control

Lean thinking proposes an operating principle: design for flow and eliminate waste. In logistics, this implies reducing lead-time variability, standardizing routines, simplifying information flows, and making system status visible [3]. In real implementations, sustainability requires a management system: short stand-ups, actionable metrics, audit routines, learning, and mechanisms to correct deviations before they become crises [4].

C. Strategic purchasing: segmentation and risk

The purchasing portfolio approach classifies items by profit impact and supplier-market complexity. Critical items (high impact, high complexity) require assurance strategies, collaboration, and contingency plans, whereas leverage items may focus on cost efficiency [5]. Supply management adds methods to select suppliers, measure performance, develop capabilities, and manage contracts, reducing vulnerability to shocks and improving supply consistency [6].

D. Planning in microenterprises: S&OP and MRP

S&OP is a recurring decision process aligning demand, capacity, and inventory over a tactical horizon. In microenterprises, it must remain lightweight: few families, explicit assumptions, clear decisions, and a dashboard with alerts. MRP translates plans into time-phased material requirements based on bills of materials and lead-time parameters [11]. Under data constraints, simple safety-stock policies and periodic review are recommended, especially for perishables or highly variable items [12].

E. Operational rationale for simulation

In queued systems, performance is non-linear: small changes in arrivals or resource availability can trigger disproportionate waiting times. As utilization approaches 1, variability dominates cycle time [13]. Discrete-event simulation is appropriate to represent such behavior and to test priority rules, sequencing, and staffing without disrupting the real system [7], [8].

III. METHODOLOGY

A. Research design

A mixed-method case study was conducted. The qualitative component built a causal explanation of the problem (process maps, root causes, decisions, and routines). The quantitative component characterized supply variability, demand patterns, and the temporal performance of the process.

B. Data sources and instruments

Sources included purchasing and inventory records, production and dispatch orders, quality and regulatory documents, semi-structured interviews, and direct observation of the purchasing–warehouse–production–dispatch flow. Diagnostic tools included cause–effect analysis, Pareto prioritization, flow mapping, and activity analysis, combined into an objective-deployment logic to fix priorities [9].

C. Analytical procedure

The procedure followed six phases: (1) process and internal-customer definition; (2) evidence collection (data and observation); (3) root-cause and loss identification; (4) intervention design; (5) AS-IS and TO-BE modeling via simulation; (6) economic and compliance assessment.

D. Simulation modeling

The model represents entities (material requirements and supply tasks), resources (key staff, storage, transport, equipment), and queues (approval, receiving, picking, dispatch). Processing times were parameterized with observed data and, when needed, distributions to represent variability. The goal was not precise point prediction but consistent scenario comparison and relative effect sizing [7], [8].

IV. CASE DESCRIPTION

A. Operational context and flow

The company produces artisanal fermented beverages (kombucha and kefir) and fermented vegetable products. Orders arrive through digital and B2B channels with short delivery promises, typically 24–48 hours depending on route [9]. This promise compresses internal response time; any supply delay rapidly becomes external noncompliance.

B. Operational symptoms

Observed symptoms cluster into: (1) weak planning—purchasing not consistently anchored to demand and seasonality; (2) process issues—non-standardized supply and dispatch routines with tacit dependencies; (3) people—competency gaps in purchasing, data, and cross-functional coordination.

C. Critical risk: seasonal inputs

Fruit sourcing exhibits the highest lead-time variability and the largest delays. The case reports an average procurement delay of 2.67 days for the most critical input, interrupting production flow, increasing rescheduling, and forcing expedite purchases [9]. This pattern is consistent with systems where supply variability dominates performance [13].

D. Compliance, quality, and governance

As management references, ISO 9001 and ISO 22000 were used to strengthen process control, traceability, and documentary consistency [14], [15]. Because the products are food and beverages, operations also fall under national public-health and food-safety requirements: the General Health Law, the food-safety framework, and the sanitary regulation for foods and beverages [16], [17], [18]. Regarding consumer information, labeling is linked to the regulation on healthy eating promotion [19]. A social responsibility perspective was also considered for practices affecting consumers and working conditions [20].

V. INTERVENTION DESIGN

A. Design principle

The intervention targets the systemic root cause: the absence of an explicit decision-and-control system. The proposed architecture integrates four components with defined cadences and accountable roles.

B. Lightweight S&OP (tactical)

The S&OP cycle is structured around minimal decisions: updating demand by family (forecast + confirmed orders), reviewing constraints (capacity and critical inputs), closing an agreed plan, and communicating operational commitments. This transforms volatility into programmable decisions and reduces last-minute changes, consistent with tactical alignment logic [2], [10].

C. MRP and inventory policies

MRP is adopted to translate the tactical plan into material requirements based on bills of materials and lead times [11]. Given microenterprise constraints, a pragmatic configuration is proposed: critical items with safety stock and simple reorder rules. For highly variable items (e.g., fruits), safety stock is justified by lead-time dispersion; for stable items (e.g., packaging), periodic review and reorder points are recommended [12].

D. Operational standardization

Standard operating procedures were defined for purchasing, receiving, storage, and dispatch, including control points for traceability, rotation, and conservation conditions. Visual control and daily routines reduce dependence on tacit memory and help detect deviations early, consistent with lean sustainment practices [3], [4].

E. Supplier management by criticality

Category segmentation was applied to focus effort on critical/high-risk items, following the portfolio approach [5]. For critical categories, the design recommends supply agreements, pre-approved alternatives, and supplier compliance metrics. Supply management frames relationships with critical suppliers as a strategic capability rather than a pure transaction [6].

F. Competency-based training plan

Training is organized into modules: data quality (records and item coding), purchasing fundamentals, internal coordination (prioritization and communication), and execution discipline (follow-up routines). The aim is to stabilize the human system operating the technical system.

TABLE 1
CRITICAL ELEMENTS AND COUNTERMEASURES (CASE)

Critical element	Case evidence and countermeasure
Fruits (seasonal inputs)	Average procurement delay of 2.67 days for the most critical input; countermeasure: MRP + delivery agreements + safety stock [9], [11], [12].
Short delivery promise	24–48 hour window conditions internal performance; countermeasure: S&OP to stabilize the plan and prioritize purchases [9].
Tacit routines	Variability in dispatch and receiving; countermeasure: standard procedures and visual control [3], [4].
Supplier governance	Risk concentrated in critical categories; countermeasure: portfolio segmentation and performance metrics [5], [6].

VI. RESULTS

A. Operational results

Case evidence indicates improved supply stability and fewer emergencies. By establishing a tactical plan and translating it into requirements, the operation reduces reactive purchases and rescheduling. Standardization reduces waiting between activities and lowers execution variability. AS-IS vs TO-BE simulation supports this direction: the TO-BE scenario shows less queue accumulation at critical points, particularly under demand peaks and supply variability, consistent with operational queueing behavior near high utilization [13].

B. Economic results

The economic-financial analysis reports investment recovery in under 18 months and an annual ROI of approximately 517% [9]. This magnitude is consistent with interventions that capture hidden inefficiency costs (expedites, waiting, rework) rather than requiring capital-intensive investments.

C. Quality, compliance, and sustainability

Standardization and improved traceability strengthen the capacity to sustain consistent controls. ISO 9001 and ISO 22000 guide process documentation, control points, and evidence, reducing the likelihood of deviations escalating into food-safety incidents [14], [15]. Alignment with national regulations supports compliance in sanitary surveillance and labeling [16], [17], [18], [19]. Finally, reduced emergencies and waste have positive sustainability and working-condition effects, aligned with social responsibility guidance [20].

VII. DEMAND ANALYSIS AND TACTICAL PLAN DESIGN

A. Rationale

In microenterprises, demand analysis is often substituted by commercial intuition. Yet even a basic analysis delivers two benefits: (i) it makes uncertainty explicit and (ii) it translates uncertainty into capacity, inventory, and purchasing decisions [2]. The goal is not a sophisticated forecast, but an operational reference that reduces reaction.

B. Volatility, mix, and campaign effects

Fermented beverages experience demand spikes linked to campaigns, seasonality, and social media dynamics. Volatility is compounded by product mix: different fermentation times and maturation constraints compete for shared resources. From a logistics standpoint, separating decisions by product families (e.g., base ferments, flavor variations, packaging formats) makes the plan governable [1], [2].

C. Translating demand to capacity

The tactical plan should connect demand to bottleneck capacity (fermentation, filling, labeling, dispatch). Near capacity limits, variability drives disproportionate waiting time, consistent with high-utilization operational principles [13]. Therefore, S&OP must focus not only on volume but also on smoothing weekly load profiles and reducing disruptive changes.

D. Finished-goods inventory policy
For perishable products, finished-goods inventory must remain limited; however, a small buffer can stabilize dispatch within a 24–48 hour promise. The recommended policy is a target inventory by family, reviewed weekly, with FEFO rotation where applicable. Inventory theory notes that when stockout cost is high, safety stock may be justified even under capital constraints if designed to minimize obsolescence [12].

E. Integration with purchasing
S&OP outputs must become a purchasing plan: requirement calendars and early alerts. This is the interface with MRP: the plan is not a document, but a signal to prevent expedites and sustain flow [11], [12].

VIII. SIMULATION SPECIFICATION, VERIFICATION, AND VALIDATION

A. Scope
The model represents the end-to-end process relevant to internal service: requirement generation, review/approval, purchasing, receiving, storage, release to production, and preparation for dispatch. Priority was given to points concentrating variability: critical-input lead times and coordination-driven waiting.

B. Entities, resources, and rules
Entities are defined as material requirements and associated supply tasks. Resources include purchasing staff, warehouse capacity, and production support for supply interactions. The model includes queues and priority rules (e.g., emergencies vs plan).

C. Parameterization and distributions
When observed data exist, modeling guidance recommends distributions representing empirical variability and avoiding unjustified assumptions [7]. Under limited data, conservative parameters and sensitivity analysis were used to check robustness.

D. Verification and validation
Verification focused on logic, routes, counters, and balances. Validation compared model behavior to observed patterns: queue emergence and urgency spikes when critical inputs are delayed, consistent with good modeling practice [7], [8].

E. Experimental design
AS-IS and TO-BE scenarios were compared using multiple replications to capture stochastic variability. The TO-BE scenario implements planning and prioritization rules (S&OP and MRP) and reduced times due to standardization. Analysis centered on waiting times, emergency frequency, and flow stability.

IX. EXTENDED RESULTS AND SENSITIVITY ANALYSIS

A. Reading the results
Results are interpreted as relative comparisons: how the system changes when decisions are governed and execution variability is reduced. Simulation indicates a consistent reduction in queue accumulation at critical points under TO-BE.

B. Sensitivity to supply shocks
Without safety policies, the system destabilizes rapidly; the 24–48 hour promise becomes difficult to sustain. With safety policies and explicit rules, the system absorbs shocks better, albeit with inventory costs that must be managed [12], [13].

C. Sensitivity to demand peaks
Without S&OP, peaks translate into emergencies and overload; with S&OP, peaks are smoothed through family prioritization and capacity decisions, consistent with the tactical planning role [2].
D. Financial interpretation
The case reports payback under 18 months and ROI around 517% [9]. While exact values depend on cost assumptions and execution discipline, the order of magnitude suggests that governing decisions captures hidden costs and generates value quickly.

X. IMPLEMENTATION, GOVERNANCE, AND CONTROL

A. Implementation roadmap
For microenterprises, sequencing determines success. A four-wave roadmap is proposed: (1) data normalization (item master, units, bills of materials) and record discipline; (2) routines and standards (SOPs for purchasing/receiving/storage/release/dispatch; visual control); (3) lightweight planning (weekly/monthly S&OP; purchasing plan) and basic MRP parameterization [2], [11]; (4) consolidation (critical-supplier scorecards, internal audits, continuous improvement, parameter recalibration). The logic is to move from "organizing" the system to "governing" it: visibility first, then rules, then optimization.

B. Roles and decision rights
A frequent failure mode is ambiguous responsibility. A minimal RACI is recommended: demand owner (consolidates orders and signals), S&OP owner (convenes and documents decisions), purchasing/supply owner (executes plan and manages suppliers), and production/dispatch owners (confirm constraints and report deviations). The S&OP forum resolves conflicts, such as allocating scarce critical inputs across families.
C. Management rituals and dashboards
Control must be frequent, short, and signal-based: daily stand-up (critical inputs, emergencies, production release, dispatch

commitments), weekly S&OP (family plan, target inventory, constraints, purchase plan), and monthly review (lessons learned, parameter updates, performance evaluation). Lean sustainment literature emphasizes these rituals as the infrastructure of improvement; without routines, operations revert to reaction mode [4].

D. Supplier scorecards and development
For critical items, a simple scorecard is proposed: on-time performance, incoming quality, quantity variance, and disruption communication. Portfolio segmentation supports effort allocation where risk is highest [5]. Supply management adds collaboration and development practices, especially in small, volatile supplier markets [6].

E. Compliance and food safety
In foods and beverages, logistics improvement must reinforce controls: receiving criteria, batch traceability, FEFO rotation, sanitation, and conservation conditions. National requirements demand sanitary surveillance and control [16], [17], [18], while ISO 22000 guides hazard management and evidence [15]. These practices reduce regulatory risk and protect business continuity.

F. Sustainability and responsibility
Reducing emergencies and waste yields environmental benefits (less scrap, better rotation) and social benefits (lower overload and overtime). ISO 26000 can guide minimum commitments to consumers and workers without bureaucratizing operations [20].

XI. LIMITATIONS AND FUTURE WORK

A. Data limitations and generalization
As in many microenterprise studies, data quality and granularity constrain inference. Simulation captures mechanisms and relative trends, but absolute precision depends on robust records and periodic recalibration [7], [8]. Generalization is most appropriate for firms with moderate product mix and comparable process structures.

B. Exogenous shocks
Two external factors can dominate performance: supply shocks (climate, seasonality, supplier-market informality) and demand shocks (campaigns, social media, regulatory changes). Therefore, the model emphasizes operational resilience—alternate suppliers, safety policies, explicit decisions—over fragile optimization [1], [2].

C. Methodological extensions
Future work may include: (1) statistical forecasting by family with explicit uncertainty; (2) robust inventory policy optimization under working-capital constraints [12]; (3) integrated supplier risk analytics based on criticality criteria [5], [6]; (4) experimental evaluation of lean sustainment routines and long-run performance [4].

D. Advanced internal and external service metrics
We recommend operationalizing internal OTIF (on-time in-full), inventory accuracy by family, and plan-stability indicators (weekly change count). Externally, delivery consistency can be correlated with internal interruptions to test the proposed causal chain.

E. Academic implication
Beyond the case, the academic contribution is showing that typical large-organization tools (S&OP, MRP, scorecards) can be translated into "lightweight versions" without losing control logic. The central challenge is institutional design: simple rules, cadences, and evidence that sustain flow under high variability.

XII. GROWTH SCENARIOS AND ROBUST DESIGN

A. Growth and operational complexity
When demand grows, not only volume increases; complexity rises via product mix, channels, and variability. In fermented beverages, growth often brings more flavors, formats, and delivery constraints. If supply remains reactive, growth amplifies hidden costs: emergencies, stockouts, expiry, and rework. Therefore, growth should be supported by robust design rather than operational heroics.

B. Capacity strategy: bottlenecks and buffering
First, identify bottlenecks (fermentation, filling, labeling, dispatch). In high-utilization systems, marginal load increases can sharply raise cycle time due to variability [13]. Three mechanisms are proposed: (i) smooth demand via S&OP and commercial agreements (e.g., route-based delivery dates), (ii) create operational buffering (small finished-goods buffers by family), and (iii) strengthen flexible capacity (cross-training).

C. Evolving S&OP
A lightweight S&OP can evolve into a monthly cycle with weekly reviews: the month sets family targets, weeks adjust with actual orders. The key is disciplined evidence: what changed, why, and what decision was taken.

D. Evolving MRP
As complexity grows, MRP risks expanding rules without data control. Evolution should focus on parameterization (lead times and safety stocks by criticality) and exception management (alerts for stockouts, supplier delays, abnormal consumption). Inventory policies should adapt to variability and stockout cost—not intuition [12].

E. Supplier resilience
In growth scenarios, the supplier portfolio must become more resilient. For critical items, single-sourcing is a structural vulnerability. Portfolio segmentation [5] should be complemented with development and collaboration practices [6]: volume agreements, delivery scheduling, quality monitoring, and contingency plans—especially for seasonal inputs.

F. Integration with quality and food safety
Growth increases exposure to incidents. Scaling must integrate traceability controls, receiving verification, and documentary evidence, aligned with ISO 22000 and ISO 9001 [14], [15], and with national regulations [16], [17], [18]. Operationally, section standards should evolve with growth without losing simplicity.

G. Simulation as a permanent laboratory Simulation should not be a one-off exercise; in small organizations it can be a periodic laboratory for growth decisions: new routes, new families, staffing changes, and inventory policies. Recalibrated with recent data, it supports trade-off analysis without experimenting in the real world, following methodological recommendations [7], [8].

TABLE II
THREATS TO VALIDITY AND PRACTICAL CONTROLS

Construct	Indicator	Definition / unit	Data source	Primary use
Internal service level	Internal OTIF	% of internal deliveries on time and in full	Production/dispatch confirmations	Outcome KPI
Internal service level	Stockout incidence	Count or % of batches delayed by shortages	Production release logs	Outcome KPI
Planning governance	S&OP adherence	% cycles executed with decisions documented	S&OP minutes / dashboard	Process control
Planning governance	Plan stability	Weekly number of plan changes	Weekly plan vs actual	Variability signal
Procurement discipline	Reactive purchase rate	% purchases classified as expedites	PO log classification	Waste proxy
Supplier performance	Lead-time compliance	% deliveries within agreed window	Receiving logs	Risk control
Execution stability	Dispatch routine compliance	% dispatches following SOP checklist	Dispatch checklist	Lean sustainment
Cost performance	Supply coordination losses	S/ per period attributable to expedites/waiting	Cost model / accounting	Economic link

Threat	How it could bias results	Control in this study	Recommended reinforcement
Seasonality confounding	Performance changes due to peak/off-peak demand	Scenario comparison via simulation; explicit seasonal narrative	Track KPIs across seasons and normalize by volume
Single-case external validity	Limited generalization beyond the firm	Mechanism articulation + protocol definition	Multi-case replication across similar producers
Measurement drift	Indicators change definition over time	Defined metrics in measurement model	Data governance: glossary + periodic audits
Hawthorne effect	Short-term improvement due to attention	Use of objective cost and logistics records	Longitudinal tracking over ≥6–12 months
Model misspecification	Simulation omits key constraints	Verification/validation steps described	Sensitivity analysis; calibrate with new operational data

A replicability protocol is recommended for future applications: (1) define internal customers and service window (e.g., 24–48 hours); (2) map the end-to-end supply flow; (3) classify items by criticality and seasonality; (4) configure a lightweight S&OP cadence; (5) implement MRP triggers for critical items; (6) standardize receiving and dispatch; (7) deploy training; (8) measure indicators monthly and run a simple sensitivity analysis for supplier delays and demand peaks. This protocol is intentionally "minimum viable" to fit microenterprise constraints.

Validity risks in case-study proceedings frequently arise from (i) single-respondent bias, (ii) post-hoc rationalization, and (iii) conflating simulation outputs with empirical observation. To mitigate these risks, the workflow should explicitly separate evidence types: observed operational patterns (queues, shortages, rework), measured indicators (OTIF, lead times, costs), and modeled counterfactuals (AS-IS vs TO-BE simulation). The proceeding's claims should be interpreted as mechanism-based: the intervention improves performance by converting implicit, reactive decisions into explicit, governed routines.

XVIII. VALIDITY, BIAS CONTROL, AND REPLICABILITY PROTOCOL

A minimal scoring rubric can be used for qualitative constructs (e.g., routine compliance), but the rubric must be standardized and audited periodically. When possible, indicators should be triangulated: for example, a reduction in expedites should co-occur with improved lead-time compliance and fewer production stoppages. Such triangulation supports convergent validity while remaining feasible for small firms.

Given the microenterprise context, the measurement model favors indicators that can be produced from routine records (purchase orders, receiving logs, inventory movements, production releases, and dispatch confirmations). Perceptual evidence from interviews is used to complement—rather than replace—objective indicators. This reduces construct contamination and supports a clearer separation between perception (satisfaction) and operational reliability.

To strengthen replicability beyond narrative description, this section operationalizes the core constructs as measurable variables. Internal service level is treated as an operational reliability construct: the probability that supply enables production and dispatch to execute the agreed plan without shortages and within the required time window. Lean logistics is treated as the presence of flow-stabilizing routines (standard work, visual control, and daily management), while supply management capability is represented through planning governance (lightweight S&OP), procurement discipline (MRP-driven triggers), and supplier performance control.

TABLE III. MEASUREMENT MODEL AND INDICATORS (OPERATIONALIZATION)

KPI	Formula / unit	Review	Alert threshold	Immediate action	Owner
Internal OTIF	% internal deliveries on time and in full	Weekly/ Monthly	< target by ≥5 pp	Identify shortage /delay cause; adjust plan and suppliers	Ops lead
Stockout incidence	# or % batches delayed by shortages	Weekly	≥1 critical event/week	Trigger expedited replenishment + root-cause ticket	Supply lead
Reactive purchase rate	% purchases marked as expedite	Weekly/ Monthly	> baseline or upward trend	Freeze noncritical buys; re-run MRP; escalate supplier delay	Supply lead
Supplier lead-time compliance	% deliveries within window	Monthly	< 90% for critical suppliers	Renegotiate windows; qualify backup; adjust safety stock	Supply + GM
Inventory record accuracy	% cycle-count match	Weekly/ Monthly	< 95% critical items	Cycle count; correct master data; retrain	Warehouse
Plan stability	# weekly plan changes	Weekly	> predefined limit	Enforce S&OP decisions; separate urgent vs planned	Commercial + Ops
Obsolescence/expiry events	# events; S/ loss	Monthly	Any critical event	Revise FIFO/FEFO; adjust buffers; review demand mix	Warehouse + QA
Coordination loss cost	S/ per period	Monthly	Rising trend	Audit bottlenecks and approval queues; simplify flow	GM
Training adherence	% modules completed	Monthly	< 90% planned	Replan; assign time blocks; measure competence pre/post	GM/HR
Complaint/return incidence	# per period	Monthly	Upward trend	Trace to internal OTIF failures; corrective action	QA/Commercial

Category	Service impact	Supply risk	Policy	Primary controls	Notes
Seasonal fruits	High	High	Assurance + buffers	Delivery windows, backup supplier, safety stock, quality checks	Highest variability; drives schedule
Cultures / starters	High	Medium	Assurance	Qualified suppliers, cold-chain handling, minimum stock	Quality sensitive
Bottles and caps	High	Low–Medium	Efficiency + continuity	Reorder points, periodic review, supplier performance	Volume leverage
Labels/packaging	Medium	Low	Efficiency	Batch ordering, approval lead time control	Avoid design-driven delays
Cleaning/ sanitation supplies	Medium	Low	Continuity	Minimum stock, consumption monitoring	Compliance relevance
Transport services	High	Medium	Assurance	Route scheduling, SLA windows, incident log	Affects 24–48h promise
Secondary ingredients	Low–Medium	Medium	Pragmatic	Simple reorder rules	Manage substitutions
Office/admin supplies	Low	Low	Administrative simplicity	Bulk purchase when needed	Avoid noise in planning

This segmentation also supports sensitivity analysis: the most critical categories are the ones where lead-time variance and quality variance should be stress-tested in simulation. By treating category strategy and KPI governance as part of the operating model—not as "extra paperwork"—the intervention becomes more transferable to other small beverage producers.

Working capital is the binding constraint in microenterprises. Therefore, category strategies must jointly optimize service reliability and inventory investment. For high-risk items with high service impact (e.g., seasonal inputs), the strategy prioritizes continuity: safety stock sized to lead-time dispersion, backup suppliers, and delivery scheduling. For stable leverage items (e.g., standardized packaging), the strategy can emphasize price efficiency and periodic review policies. For low-impact items, the strategy is administrative simplicity.

Supplier and category strategy determines whether planning is executable. In fermented beverages, critical categories typically include seasonal fruits, cultures, and packaging materials that directly constrain production. A portfolio approach segments categories by (i) profit/service impact and (ii) supply risk. The segmentation is practical: it defines how much managerial attention each category deserves and what governance instruments are required (agreements, backups, audits, or simple ordering).

XX. SUPPLIER PORTFOLIO, CATEGORY STRATEGY, AND WORKING-CAPITAL LOGIC

The dashboard should be interpreted as a set of linked signals, not isolated numbers. A decline in lead-time compliance should precede a rise in reactive purchasing and, if not corrected, a rise in stockouts and internal OTIF deterioration. This causal chain is the core mechanism that the intervention seeks to control.

Control limits should be pragmatic. For example, internal OTIF can be targeted to increase gradually; the critical point is to define what counts as "on time" and "in full" and to keep this definition stable. Similarly, lead-time compliance should be tracked by supplier and category, because category-level aggregation can hide the true source of instability. Reactive purchasing should be treated as a waste proxy: when it rises, it signals that planning governance is not functioning or that supplier performance is deteriorating.

XIX. KPI DASHBOARD, CONTROL LIMITS, AND DECISION RULES

To move from "project" to "operating system," the firm requires a small set of metrics with explicit decision rules. In microenterprises, dashboards fail when they are either too complex or disconnected from actions. Therefore, each KPI should answer a decision question: What must be done if the KPI crosses a limit? The dashboard below is intentionally small and is designed to be reviewed within 15–20 minutes in the weekly cycle and within 45 minutes in the monthly cycle.

TABLE IV

KPI DASHBOARD AND DECISION RULES

Condition	Why it matters	Minimum evidence	If absent, do this first
Defined internal customer and service window	Service level requires a time/quantity definition	Documented 24–48h window (or equivalent)	Define window + acceptance tolerances
Item master and units of measure	MRP and inventory accuracy depend on master data	Stable SKU list + units	Normalize SKUs and units; remove duplicates
Basic BOM and lead-time parameters	MRP needs consumption and timing	BOM for key products; lead times for critical items	Create minimal BOM; estimate lead times
Receiving and inventory movement logging	Without logs, KPIs are not computable	Receiving log + issuance log	Start paper log; migrate later to spreadsheet
Supplier list with criticality labels	Category strategy requires segmentation	Critical vs noncritical classification	Run a one-hour segmentation workshop
Weekly planning ritual	Cadence converts volatility into decisions	Standing weekly meeting + minutes	Create short agenda and a dashboard
Named owners for KPIs	Metrics without owners do not drive action	Owner column filled in dashboard	Assign owners and review responsibilities
Training schedule	Competence is a constraint in micro-firms	Module plan with dates	Start with data discipline and SOPs
Incident/complaint log	Service failures need learning loop	Simple incident register	Start a one-page incident log

If these conditions are met, replication is primarily an execution challenge. If they are not met, the firm should not attempt advanced simulation or comprehensive supplier programs; instead, it should first stabilize records and cadences. This sequencing reduces failure risk and aligns improvement with microenterprise capacity.

Implementation should prioritize the "thin waist" of the operating system: a single dashboard, a single S&OP cadence, and a small number of non-negotiable records (purchase order, receiving, inventory movements, production release, dispatch confirmation). This avoids the typical failure of introducing many documents that are not used in decisions. The control plan and KPI dashboard provided earlier are designed to keep the system light while still auditable.

Transferability depends on boundary conditions. The model is most suitable for microenterprises with: (i) short delivery promises, (ii) moderate product variety, (iii) at least one high-variability critical input (seasonal or quality-sensitive), and (iv) limited planning capacity concentrated in a small number of people. If the firm's delivery window is long and demand stable, the ROI of governance may be lower; conversely, when the delivery window is short and variability high, governance tends to deliver disproportionate gains by preventing emergencies.

The proceeding's results should be interpreted as a blueprint for "minimum viable professionalism" in supply management for small beverage producers. The central managerial insight is that performance gains come less from sophisticated analytics and more from institutional design: explicit cadences (S&OP),

simple triggers (MRP/reorder rules), and disciplined execution (standard work, visual control, and short reviews). When these elements are absent, microenterprises compensate with managerial heroics, which are costly and non-scalable.

REFERENCES

[1] M. Christopher, Logistics & Supply Chain Management, 5th ed. Harlow, UK: Pearson, 2016.

[2] S. Chopra and P. Meindl, Supply Chain Management: Strategy, Planning, and Operation, 7th ed. Boston, MA, USA: Pearson, 2019.

[3] J. P. Womack and D. T. Jones, Lean Thinking: Banish Waste and Create Wealth in Your Corporation, 2nd ed. New York, NY, USA: Free Press, 2003.

[4] J. B. R. Hines, P. Found, G. Griffiths, and R. Harrison, Staying Lean: Thriving, Not Just Surviving. Boca Raton, FL, USA: CRC Press, 2018.

[5] P. Kraljic, “Purchasing must become supply management,” Harvard Business Review, vol. 61, no. 5, pp. 109-117, 1983.

[6] R. B. Handfield, R. M. Monczka, J. L. Giunipero, and J. L. Patterson, Sourcing and Supply Chain Management, 6th ed. Boston, MA, USA: Cengage Learning, 2016.

[7] A. M. Law, Simulation Modeling and Analysis, 5th ed. New York, NY, USA: McGraw-Hill Education, 2015.

[8] W. D. Kelton, J. S. Smith, D. T. Sturrock, and D. C. Standridge, Simulation with Arena, 6th ed. New York, NY, USA: McGraw-Hill Education, 2015.

[9] R. Arango Taquire, C. Castilla Calderón, F. Gamero Pérez, C. Rojas Flores, and E. Santos Enríquez, “Gestión de abastecimiento como factor clave para mejorar el nivel de servicio al cliente en una empresa productora de bebidas artesanales,” Trabajo de investigación, Universidad ESAN, Lima, Perú, 2025.

[10] D. M. Lambert, Supply Chain Management: Processes, Partnerships, Performance, 4th ed. Sarasota, FL, USA: Supply Chain Management Institute, 2014.

[11] J. Orlicky, Material Requirements Planning: The New Way of Life in Production and Inventory Management. New York, NY, USA: McGraw-Hill, 1975.

[12] E. A. Silver, D. F. Pyke, and R. Peterson, Inventory Management and Production Planning and Scheduling, 3rd ed. New York, NY, USA: Wiley, 1998.

[13] W. J. Hopp and M. L. Spearman, Factory Physics, 3rd ed. Long Grove, IL, USA: Waveland Press, 2011.

[14] International Organization for Standardization, ISO 9001:2015 Quality management systems - Requirements. Geneva, Switzerland: ISO, 2015.

[15] International Organization for Standardization, ISO 22000:2018 Food safety management systems - Requirements for any organization in the food chain. Geneva, Switzerland: ISO, 2018.

[16] Congreso de la República del Perú, Ley N° 26842, Ley General de Salud, 1997.

[17] Congreso de la República del Perú, Decreto Legislativo N° 1062, Ley de Inocuidad de los Alimentos, 2008.

[18] Ministerio de Salud del Perú, Decreto Supremo N° 007-98-SA, Reglamento sobre Vigilancia y Control Sanitario de Alimentos y Bebidas, 1998.

[19] Ministerio de Salud del Perú, Decreto Supremo N° 017-2017-SA, Reglamento de la Ley de Promoción de la Alimentación Saludable para Niños, Niñas y Adolescentes, 2017.

[20] International Organization for Standardization, ISO 26000:2010 Guidance on social responsibility. Geneva, Switzerland: ISO, 2010.