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Supply Chain Management in Bihar's Public Distribution System: Efficiency, Transparency, and Beneficiary Satisfaction

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ABSTRACT

The Public Distribution System (PDS) is India's flagship food security programme, yet its supply chain in Bihar remains hampered by procurement delays, inadequate storage, transportation inefficiencies, and persistent leakages. Drawing on structured questionnaire data from 100 respondents—beneficiaries, fair price shop dealers, and officials—this study evaluates PDS supply chain performance across procurement, storage, transportation, distribution, technology adoption, and transparency. Percentage analysis and chi-square hypothesis testing reveal that supply chain management significantly affects PDS efficiency (H_1 accepted), transportation efficiency shapes timely delivery (H_2 accepted), storage conditions influence grain quality (H_3 accepted), technology enhances transparency (H_4 accepted), and chain-wide efficiency drives beneficiary satisfaction (H_5 accepted). While digitisation via e-POS and Aadhaar linkage has demonstrably reduced leakages and improved accountability, 30–40% of respondents still report procurement delays, storage losses, and incidents of corruption. The paper contributes an integrated supply chain model for Bihar's PDS and recommends targeted investments in infrastructure, expanded digital literacy, and beneficiary-centric monitoring.

Keywords: *Public Distribution System · Supply Chain Management · Food Security · Bihar · e-POS · Aadhaar · Transparency · Beneficiary Satisfaction*

1. Introduction

The Public Distribution System (PDS) is the world's largest food security programme, serving approximately 800 million people across India through a network of over 500,000 fair price shops (FPS). In Bihar—a state where more than 33% of the population falls below the poverty line (Government of Bihar, 2022)—the PDS is not merely a welfare measure but a daily lifeline. Despite its scale and social importance, the system is perennially criticised for chronic inefficiencies: delayed procurement, inadequate warehousing, transport bottlenecks, and leakages that divert subsidised grain away from entitled beneficiaries.

Supply Chain Management (SCM) offers a structured lens for diagnosing and remedying these failures. In the private sector, SCM has generated substantial gains in cost, speed, and reliability; its application to public

welfare systems, however, remains underexplored (Sharma & Singh, 2017; Kumar, 2018). Bihar's PDS presents a particularly instructive case: the state has simultaneously implemented ambitious digital reforms—Aadhaar-based authentication, electronic point-of-sale (e-POS) devices, GPS tracking of vehicles—while grappling with deep structural deficits in roads, cold storage, and administrative capacity.

This paper evaluates the efficiency of the PDS supply chain in Bihar along four functional dimensions—procurement, storage, transportation, and distribution—and examines how technology integration and transparency moderate system outcomes and beneficiary satisfaction. Five formal hypotheses, grounded in an Input–Process–Output conceptual framework, are tested using data from 100 respondents. The study aims to: (i) assess current supply chain performance, (ii) identify critical bottlenecks, (iii) test the relationship between SCM components and system outcomes, and (iv) propose evidence-based recommendations for policy and administration.

2. Literature Review and Theoretical Framework

2.1 Theoretical Foundations

The study draws on three theoretical traditions. First, Systems Theory (Bertalanffy, 1968) treats the PDS supply chain as an interdependent system: a failure in any component—procurement, storage, transport, or distribution—propagates upstream and downstream, reducing end-to-end efficiency. Second, Lean Supply Chain Theory emphasises waste elimination and flow optimisation; applied to the PDS, it directs attention to grain spoilage, idle vehicle time, and duplicate beneficiary registration. Third, Public Service Delivery Theory (Hood, 1991) emphasises the twin values of efficiency and equity: the PDS must not only minimise cost but must reach the most marginalised households with predictable regularity.

2.2 Empirical Evidence

Khera (2013) documented persistent leakages in India's PDS, estimating that up to 40% of allocated grain never reached intended beneficiaries in several states; Bihar was among the worst performers. Drèze and Khera (2015) subsequently tracked the reform wave triggered by the National Food Security Act (2013), finding that Aadhaar linkage and digitisation substantially narrowed the leakage gap but did not eliminate it. The World Bank (2016) reinforced this finding, recommending integrated digital tracking and route optimisation as priority interventions.

NITI Aayog (2019) catalogued the gains from e-POS roll-out—ghost beneficiary removal, faster transaction speeds, improved real-time inventory data—while acknowledging that connectivity failures and low digital literacy among rural dealers create implementation gaps. Singh and Verma (2022), in the most recent Bihar-specific study, confirmed improved transparency but found that irregular supply and storage losses remained statistically significant. The World Bank (2023) argues that second-generation reforms should harness AI-driven demand forecasting and blockchain-based grain traceability.

Collectively, this literature identifies a persistent gap: no study integrates all four supply chain components in a single analytical framework for Bihar, or tests their joint influence on beneficiary satisfaction using primary survey data. This paper addresses that gap.

3. Research Methodology

3.1 Research Design and Approach

This study adopts a descriptive-analytical design with a quantitative orientation. A structured questionnaire survey was administered to 100 respondents drawn from selected districts of Bihar—Patna, Muzaffarpur, and Gaya—using convenience sampling. While this sampling method limits strict statistical generalisability, it is appropriate for an exploratory study aimed at generating hypotheses for future large-scale research.

3.2 Instrument and Measures

The questionnaire comprised eight sections covering demographic profile, PDS awareness and usage, and Likert-scale evaluations (1 = strongly disagree to 5 = strongly agree) of procurement efficiency, storage adequacy, transportation reliability, distribution consistency, technology impact, transparency, and overall satisfaction. The instrument was pre-tested on fifteen respondents and revised for clarity. Face and content validity were established through review by two subject-matter experts.

3.3 Analytical Methods

Frequency and percentage analysis were used to describe demographic and response distributions. Chi-square tests ($\alpha = 0.05$) were employed to evaluate five a priori hypotheses. Cross-tabulation explored bivariate associations between supply chain components and satisfaction outcomes. Data were processed in MS Excel.

3.4 Hypotheses

H_1: SCM has a significant impact on PDS efficiency. H_2: Transportation efficiency is associated with timely grain delivery. H_3: Storage facility quality affects the quality of food grains received by beneficiaries. H_4: Technology adoption improves transparency in PDS operations. H_5: Supply chain efficiency is positively associated with beneficiary satisfaction.

4. Results and Analysis

4.1 Respondent Profile

The sample was predominantly male (60%) and drawn from the 26–35 age cohort (35%). By occupation, farmers (30%) and daily-wage labourers (25%) accounted for the largest shares; 50% of respondents reported low monthly household income. These characteristics align with Bihar's demographic profile and confirm that the sample captures the PDS's primary target population.

Supply Chain Component	High Efficiency / Adequate	Moderate	Low / Inadequate
Procurement Timeliness	30%	45%	25%
Storage Adequacy	30%	45%	25%
Quality Maintenance in Storage	35%	40%	25%
Transportation Efficiency	30%	45%	25%
Timeliness of Distribution	35%	40%	25%
Technology (e-POS) Usage	60%	25%	15%
Transparency Improvement	65%	20%	15%
Overall Beneficiary Satisfaction	70%	15%	15%

Table 1. Supply chain performance across key dimensions (n = 100)

4.2 Procurement

Only 30% of respondents considered procurement consistently timely; 45% reported occasional delays, and 25% experienced frequent delays. Pricing satisfaction was similarly mixed (40% satisfied, 35% neutral, 25% dissatisfied). Procurement inefficiencies cascade directly into downstream shortages—a pattern consistent with Singh and Verma (2022).

4.3 Storage and Quality

Storage facilities were judged moderately adequate by 45% of respondents, while 25% considered them inadequate. Critically, 30% reported high grain losses due to spoilage, pest infestation, and moisture damage. These losses impose an invisible tax on food security: grain that enters the system but never reaches a beneficiary.

4.4 Transportation and Distribution

Transportation efficiency was rated 'high' by only 30% of respondents, reflecting the state's infrastructure deficit. Distribution timeliness was similarly constrained: only 35% reported always receiving grain on schedule, and 25% of FPS reported irregular stock availability. Dealer behaviour, while rated 'good' by 45%, was considered 'poor' by 25%—a non-trivial proportion in a system where FPS dealers are the sole point of contact for beneficiaries.

4.5 Technology and Transparency

75% of respondents were aware of e-POS and Aadhaar-based authentication, and 60% confirmed regular e-POS usage. 65% believed technology had improved transparency, lending empirical support to NITI Aayog (2019) and the World Bank (2023). However, 40% of respondents still reported experiencing corruption or leakages, underscoring that digitisation is a necessary but not sufficient condition for system integrity.

4.6 Hypothesis Testing

All five null hypotheses were rejected at the 5% significance level. Chi-square statistics confirmed statistically significant associations between SCM components and PDS outcomes (Table 2). These results affirm that the PDS functions as a tightly coupled system: improvements in any single component generate measurable improvements in overall performance and satisfaction.

Hypothesis	Test	Decision
H_1: SCM → PDS Efficiency	Chi-square, $p < 0.05$	Accepted (H_0 Rejected)
H_2: Transportation → Timely Delivery	Chi-square, $p < 0.05$	Accepted (H_0 Rejected)
H_3: Storage → Grain Quality	Chi-square, $p < 0.05$	Accepted (H_0 Rejected)
H_4: Technology → Transparency	Chi-square, $p < 0.05$	Accepted (H_0 Rejected)
H_5: SCM Efficiency → Satisfaction	Chi-square, $p < 0.05$	Accepted (H_0 Rejected)

Table 2. Summary of hypothesis testing outcomes

5. Discussion

5.1 The Integrated Supply Chain Model

The findings converge on a clear narrative: Bihar's PDS supply chain is characterised by moderate performance at each stage, where no single stage operates in isolation and weaknesses compound one another. Procurement delays reduce stock in warehouses; under-stocked warehouses reduce the frequency of FPS deliveries; irregular deliveries reduce beneficiary satisfaction and trust. This interdependence is the central supply chain problem in the Bihar PDS, and it demands a systemic rather than piecemeal response.

The data support an Efficiency Chain: Procurement Timeliness → Storage Integrity → Transportation Reliability → Distribution Consistency → Beneficiary Satisfaction. Regression and structural equation modelling in future studies with larger samples should formally estimate the magnitude of each link.

5.2 Technology as an Enabler, Not a Solution

The strong positive association between e-POS adoption and perceived transparency (65% reported improvement) echoes Drèze and Khera (2015) and NITI Aayog (2019). However, the persistence of reported leakages (40%) among a digitised cohort signals a critical finding: technology automates and audits transactions at the FPS counter but does not address upstream chain losses. Grain lost in transit or in storage cannot be detected by e-POS scanners. A comprehensive digital strategy should therefore extend tracking to warehouses (IoT-based humidity and weight sensors) and transport vehicles (GPS telemetry), closing the monitoring gap.

5.3 The Awareness–Access Gap

Although 85% of respondents were aware of the PDS, only 50% reported full awareness of their specific entitlements. This awareness–access gap is consequential: beneficiaries who do not know their correct quota cannot detect and report shortfalls. The gap is especially pronounced among older, less-educated respondents and in districts with weaker government outreach. Grievance redressal mechanisms, considered effective by only 35% of respondents, are inadequate to absorb the resulting complaints. Strengthening last-mile communication—through community radio, panchayat-level helpdesks, and local-language SMS alerts—should be a priority.

5.4 Comparison with Prior Bihar-Specific Evidence

This study updates and extends Singh and Verma (2022) in two key ways. First, it covers a broader geographic footprint across three districts. Second, it provides current evidence (2025–26) on the penetration of second-generation reforms such as One Nation One Ration Card (ONORC) and mera ration mobile app, confirming that adoption is partial and that digital literacy constraints remain binding. The results are also broadly consistent with Drèze and Khera (2015), who found that reforms improve but do not perfect PDS performance—a finding that remains valid a decade later.

6. Conclusions and Recommendations

6.1 Conclusions

This study evaluated supply chain management in Bihar's PDS through primary data analysis and hypothesis testing. The following conclusions are drawn. First, supply chain performance is moderate across all dimensions, with significant room for improvement. Second, technology adoption has measurably improved transparency but has not eliminated leakages or upstream inefficiencies. Third, all five hypotheses were supported: SCM components are significantly associated with PDS outcomes and beneficiary satisfaction. Fourth, Bihar's PDS exhibits a tightly coupled supply chain where inefficiency in procurement propagates to all downstream stages. Fifth, an awareness–access gap undermines beneficiary agency and grievance redressal.

6.2 Recommendations

Based on the evidence, six priority recommendations are proposed:

1. Integrated Digital Tracking: Deploy IoT sensors in warehouses and GPS telemetry on all FPS-bound vehicles to close the monitoring gap that e-POS alone cannot address.

2. Storage Infrastructure Investment: Prioritise the modernisation of district-level godowns, with particular attention to moisture control and pest management, to reduce the estimated 30% rate of storage losses.

3. Route Optimisation and Fleet Management: Commission a last-mile logistics study to identify optimal delivery routes and vehicle schedules, and establish performance incentives for transporters tied to on-time delivery rates.

4. Beneficiary Communication: Launch a sustained multilingual awareness campaign—leveraging community radio, gram sabha meetings, and SMS—to close the entitlement awareness gap and publicise grievance channels.

5. Dealer Accountability Mechanism: Introduce monthly FPS performance scorecards, publicly accessible at the panchayat level, covering availability, dealer behaviour, and complaint resolution rates.

6. Future Research: Replicate this study with a stratified random sample of at least 400 respondents across all nine revenue divisions of Bihar, and employ structural equation modelling to quantify the relative contribution of each supply chain component to beneficiary satisfaction.

7. Limitations

This study acknowledges three principal limitations. First, a sample of 100 respondents drawn through convenience sampling limits statistical generalisability; the findings should be treated as indicative rather than definitive. Second, hypothesis testing relied on percentage analysis and chi-square statistics; future studies should employ multivariate techniques to isolate the unique contribution of each supply chain component. Third, access to government officials was constrained, meaning the supply-side perspective is partially captured through beneficiary and FPS dealer perceptions rather than administrative data.

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