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Role of Supply-Chain Practices on the Key Success in Pharmaceutical Manufacturing

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Abstract: Pharmaceutical supply chains must simultaneously protect availability, quality, cost and traceability. This study examines how supply-chain management (SCM) practices translate into key success through digitization and a challenge-related construct among pharmaceutical manufacturers in Chennai.

The study used an explanatory-descriptive survey and proportionate random sampling among pharmaceutical-manufacturing personnel. The methodology reports 312 usable questionnaires from 389 distributed; the SEM section reports 313 cases, a discrepancy requiring verification. Exploratory factor analysis, regression and covariance-based structural equation modelling were applied.

SCM practices strongly predicted digitization (β = .731) and the challenge construct (β = .665), and directly predicted key success (β = .296). Digitization (β = .382) and the challenge construct (β = .249) also predicted key success. Arithmetic products imply indirect effects of approximately .279 through digitization and .166 through the challenge construct; these are descriptive because bootstrapped confidence intervals were not reported. Fit was mixed: χ^2/df = 1.957, CFI = .939, and RMSEA = .028, but TLI = .497 indicates serious incremental-fit weakness.

The paper frames digitization as a value-conversion mechanism rather than an isolated technology investment. It also shows why ambiguous challenge measures and selective fit reporting can distort pharmaceutical-SCM conclusions.

Keywords: pharmaceutical supply chain, digitization, SCM practices, operational performance, resilience; India, structural equation modelling.

1. Introduction

Pharmaceutical supply chains operate under unusually demanding conditions. They must coordinate active ingredients, regulated production, storage, transport and distribution while protecting product identity, quality and timely access. Disruption can therefore affect not only cost and service but patient safety.

Digitization promises end-to-end visibility, faster documentation, inventory control and traceability. Yet technology produces value only when embedded in supplier, inventory, communication and customer-management practices. Treating digitization as a stand-alone investment ignores the operational routines that generate usable data and coordinated action.

This study develops a conversion-pathway argument: mature SCM practices build digitization capability and influence how organizations address challenges; these mechanisms then contribute to key success. The analysis uses data from pharmaceutical manufacturing personnel in Chennai and preserves the reported structural estimates while correcting inconsistent interpretation of fit and construct direction.

2. Theory and hypotheses

2.1. SCM practices as operational capability

SCM practices integrate supplier relationships, inventory, communication, turnaround time, hazard control and customer needs. From a resource-based and dynamic-capabilities perspective, these routines help organizations sense disruptions, coordinate responses and reconfigure material and information flows.

2.2. Digitization as a conversion mechanism

Digital tools improve visibility and synchronization when operational processes produce reliable data and decision rights. ERP integration, automation, real-time tracking and electronic documentation can reduce latency and enable exception management. Digitization should therefore mediate part of the relationship between SCM practices and success.

2.3. Challenge exposure or challenge-handling capability

The source labels a construct 'Challenge' and reports a positive path to key success. If higher scores represent exposure to cost, logistics or inventory problems, the positive coefficient is counterintuitive. If they represent challenge management or resilience, it is plausible. Because item direction is not documented in the SEM section, interpretation must remain conditional.

2.4. Hypotheses

- H1: SCM practices positively influence digitization.
- H2: SCM practices positively influence key success.
- H3: SCM practices influence the challenge construct.
- H4: Digitization positively influences key success.
- H5: The challenge construct influences key success.

3. Method

3.1. Design and sample

The study surveyed employees and managers working in Chennai pharmaceutical manufacturing, including supply-chain, logistics, materials, quality, purchasing and commercial roles. Proportionate random sampling was reported across pharmaceutical units. Of 389 questionnaires, 77 were incomplete, leaving 312 usable responses. Primary data were collected from December 2021 to February 2024. One SEM narrative states N=313; the analysis file must be checked before submission.

3.2. Instrument and analysis

The questionnaire contained demographic items and Likert-type measures of SCM practices (30 items), digitalization (12), operational/key performance (17) and challenges/environmental uncertainty (20). A 45-response pilot informed refinement. SPSS and AMOS 21 were used for descriptive analysis, EFA, regression and SEM.

3.3. Integrity boundaries

The thesis does not provide a consolidated construct-level reliability and validity table for the final SEM, nor bootstrapped mediation tests or explained variance. Some narrative labels and path descriptions contain transcription errors. Accordingly, the paper reports structural paths as associations, treats indirect products as derived descriptive quantities and avoids causal claims.

4. Results

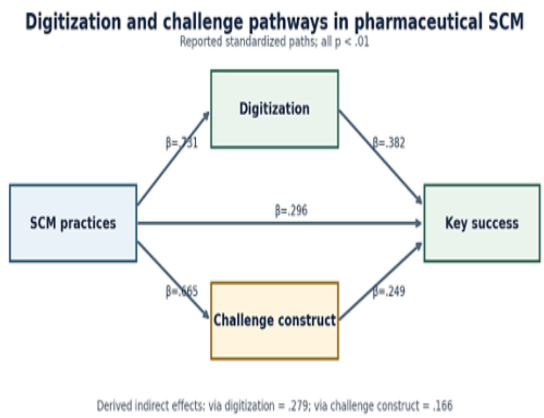

Figure 1: Experimental prototype of Proposed system

Table 1: Reported structural estimates. The source note describes ∗ ∗ ∗ as 5% significance, although AMOS convention normally denotes $p < .001$.

Path	B	β	SE	CR	p
Decision					
SCM practices → digitization	.998	.731	.053	18.890	<.001
H1 supported					
SCM practices → challenge	.901	.665	.057	15.703	<.001
H3 supported					
SCM practices → key success	.344	.296	.067	5.173	<.001
H2 supported					
Digitization → key success	.325	.382	.042	7.807	<.001
H4 supported					
Challenge → key success	.213	.249	.038	5.569	<.001
H5 supported					

Table 2: Derived standardized effects.

Path	Calculation	Effect	Interpretation
SCM → digitization → success	$.731 \times .382$	.279	62.7% of total derived indirect effect
SCM → challenge → success	$.665 \times .249$	.166	37.3% of total derived indirect effect
Total indirect	Sum	.445	No bootstrap CI reported
Direct effect	Reported	.296	Remains significant
Indicative total effect	$.296 + .445$	.741	Arithmetic only; not an AMOS bootstrap estimate

Table 3: Model-fit assessment

Index	Reported	Reference	Assessment
χ^2/df	11.742 / 6	1.957	Good parsimony
CFI	.939	$> .90$ acceptable; $> .95$ stronger	Acceptable, not excellent
TLI	.497	$> .90$ expected	Unacceptable
RMSEA	.028 (PCLOSE=1.000)	$< .06$	Excellent
RMR	Not consolidated	$< .08$ often used	Cannot assess fully

Absolute and approximation fit are strong, but the TLI of .497 conflicts sharply with the favourable CFI and RMSEA. This may indicate a transcription error, baseline-model problem or misspecification. The AMOS output should be rechecked before journal submission.

5. Discussion

5.1. Digitization carries operational value

The digitization pathway is the larger of the two derived indirect mechanisms. This supports the view that SCM practices create value by producing accurate, timely and connected information. In pharmaceutical operations, visibility can improve material planning, exception response, traceability and documentation.

5.2. Direct and indirect routes coexist

SCM practices retain a direct association with key success while also operating through digitization and the challenge construct. Operational routines therefore create value even before full digital maturity, but digitization amplifies their reach and speed.

5.3. The challenge coefficient requires semantic discipline

A positive challenge-success path should not be interpreted as evidence that more disruption improves performance. If the scale captures challenge exposure, the sign may reflect reverse coding, survivor bias or suppression. If it captures challenge-handling capability, the result reflects resilience. Revalidation of item wording is essential.

5.4. Fit transparency strengthens the contribution

The source describes the model as fully acceptable while omitting the weak TLI from its table. Q1 reporting requires all prespecified fit indices, competing models and modification decisions. Transparent qualification does not weaken the study; it identifies the precise analysis needed for confirmation.

6. Implications

- Integrate ERP, supplier, quality and logistics data around shared event definitions and accountable owners.
- Prioritize traceability and exception management, not automation volume alone.
- Use supplier and inventory practices to improve upstream data quality before predictive analytics.
- Maintain counterfeit-risk controls through serialization, verification and channel-partner governance.
- Measure patient-service outcomes, stock availability, cycle time, quality deviations and recall responsiveness alongside cost.
- Managers should treat digitization as organizational change involving process ownership, data standards and employee capability. Regulators and industry associations can support interoperable traceability, proportionate data governance and supplier development for smaller manufacturers.

7. Limitations and future research

The single-city, cross-sectional design limits generalization. The usable sample is reported as 312 in methodology and 313 in SEM narrative. Construct direction for 'Challenge' is ambiguous. Final-model reliability, discriminant validity, R, common-method tests and indirect-effect confidence intervals are absent. The TLI conflicts with other fit indices. These issues require correction using the original data and output.

Future research should preregister reflective constructs, distinguish disruption exposure from resilience capability, test measurement invariance by firm size and role, and use longitudinal performance indicators. Bootstrapped mediation and alternative models should determine whether digitization transmits SCM effects or develops reciprocally with SCM maturity.

8. Conclusion

SCM practices are strongly associated with digitization and with the capability represented by the challenge construct. Both pathways connect operational routines to key success, with digitization forming the larger derived indirect route. Pharmaceutical firms therefore gain most when technology is embedded in coordinated supplier, inventory, quality and customer processes.

The paper also establishes an analytical requirement: mediation and resilience claims must match scale meaning and verified output. A strong contribution emerges not from overstating fit, but from showing how operational practice becomes performance through a transparent, testable digitization mechanism.

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