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Smart Supplier Visibility and Inventory Tracking Framework for Reducing Child-Part Shortages in Automotive Manufacturing: Evidence from a Tier-1 Component Plant in India

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Abstract **- Low part availability, known as bought-out parts, can prevent an automotive assembly line, but many Tier-1 automotive plants are still manually chasing suppliers for parts. In this paper, child-part inventory and supplier and quality data from a tier-1 component plant in Pune, India (143 child parts, 15 supply sources, 02 production lines and April-June 2026) is analyzed and a framework called Smart Supplier Visibility and Inventory Tracking Framework (SIAD) is proposed. Only about 7 days coverage of the parts, but 91 out of 140 parts (65%) had part coverage of less than 3 days more than seven times. 60% of the parts are supplied by one source and 34% by the top five sources of supply; one fastener supplier has a lead time of 10 days, compared with 1-3 days for all other suppliers; only 6 of 60 fastener suppliers' quality issues are closed (10% of total issues). SIAD includes five modules: inventory tracking, supplier portal, smart alerts with a lead-time adjusted threshold, quality feedback and purchase dashboard, along with an escalation matrix and a phased roadmap. The framework is conceptual and has not been tried yet, and parameters are suggested for the evaluation of a pilot.**

Key Words **- supply chain visibility, inventory coverage, child-part shortage, supplier portal, lead-time-based alerts, quality management, automotive manufacturing**

I. INTRODUCTION

The auto-component sector generated a record turnover of INR 7.6 lakh crore (USD 85.9 billion) in FY2025-26, which increased by 12.7% in rupee terms and by 16.3% in terms of supply to original equipment manufacturers (OEMs) [1]. The more volume a Tier-1 plant processes, the higher the demand for more parts that are bought-out parts (BOPs) that will be used directly on the assembly line. The minimum buffer stock plants that operate on the lean and just in time (JIT) principle [2] have, therefore, very little buffer stock, and a late delivery of even a low-cost component can cause disruption of production, delay the dispatch and strain the purchasing team.

At this plant, child-part inventory is conducted physically and is then supplemented by a telephonic approach to suppliers when stock levels drop, as well as via messaging and e-mail. Suppliers are also affected by a shortage of raw materials, failure of the dies, power outages, and transport delays, which are only detected after the coverage is critical. Supply-chain visibility, defined as the ability to get accurate and timely data from partners and across functional boundaries [3], [4] is generally seen as a cure, while the lack of timely or accurate information is known to be a multiplier of supply variability [5]. Also, operations and supply management 4.0 [6] places digital tools as enablers of proactively controlling operations. Less common, but also possible, are plant-level studies that quantify the frequency of the occurrence of individual parts and then translate this into a tangible design taking into account lead time.

The paper aims to address the following goals: (i) understanding of the current practice of child-part inventory monitoring and supplier follow-up; (ii) Supplier-wise information regarding part distribution, inventory coverage, lead time, and supplier quality-defect information; (iii) Main problems of manual tracking and delayed supplier communication; and (iv) Proposing a digital framework of Lead-time based alerts and supplier specific quality-defect information.

The contributions include a part-level quantification of shortage exposure indicating that the average coverage is acceptable but that the risk of critical shortage is high; and SIAD, a framework consisting of five modules containing an explicit lead-time adjusted threshold rule, an escalation matrix and a phased implementation road map.

The literature review is presented in Section II, followed by a setting and method description in Section III, the presentation of SIAD in Section IV, the presentation and discussion of the results in Section V, implications for implementation in Section VI, limitations and future work in Section VII, and conclusions in Section VIII.

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II. LITERATURE REVIEW

A. Inventory Coverage and Safety Stock

The economic order quantity (EOQ) model [7] considers the combination of ordering and holding costs for a stable demand and reorder-point systems replenish when the stock level is expected to reach the demand rate of the supplier lead time plus a safety margin [8]. Safety stock is usually determined as

$$SS = Z\,\sigma_d\,\sqrt{L} \quad (1)$$

where Z is the service-level factor, σd is the standard deviation of the demand per period and L is the replenishment lead time [8].

$$C_i = (S_i + W_i) / D_i \quad (2)$$

where, Si is physical stock, Wi is line stock and Di is average daily consumption. If lead times are not similar (as they may not be), a single coverage threshold for all parts is protective only if the lead times are similar (testing this assumption is done in Section V).

B. Visibility, Information Distortion and Supplier Relationships

Visibility is the ability to have correct timely information on inventory, orders and shipments across organizational lines [3] [9]. In parts of the system where it is absent, there are small changes upstream amplified as information propagates (bullwhip effect [5] – reactive decisions). Supply-chain management frameworks suggest that the suppliers can be distinguished by criticality level and then communicated accordingly [10] and that Vendor-managed Inventory (VMI) should be used so that the supplier knows the buyer's stock position and can plan for proactively dispatching products [8, 10]. ABC (Pareto) logic ensures that the most parts are monitored by focusing on a few suppliers.

C. Lean, JIT and Digital Supply Chains

Lean and JIT systems [2] [11] minimize buffers and consequently increase the usefulness of timely information. These strands combine to drive a design that (a) shares stock and lead time with suppliers; (b) sends alerts when coverage falls below lead time, not a flat rule, and (c) connects quality feedback to stock and lead time.

D. Supplier Management and Risk

Supplier-management research stresses that value is created or lost at the buyer–supplier interface. Single-source dependence and capacity failures and transport disruptions are discussed in risk-management casebooks, and performance measurement and joint problem solving and structured communication with key suppliers are laid emphasis in supplier-management texts [12, 13]. At the auto-component plant, these ideas come down to three questions that can be answered by the case study: What suppliers do they focus on? What is the lead time for each supplier compared to the stock cover available? Are quality problems tied to their supplier closure?

E. Research Gap

Concepts include visibility, VMI, lean and industry or firm-level cases are presented in the literature. Outside of the sources reviewed here, there is less part-level evidence of actual part operation occurrence of critical parts, combined with lead-time aware alert logic, supplier specific quality feedback. This paper provides this evidence from one Tier-1 plant and seeks to develop a framework from it.

III. CASE SETTING AND METHODOLOGY

A. Setting

The case is the B-39 plant of Belrise Industries Ltd (BID), a Tier-1 automotive component maker that provides chassis, polymer, suspension, body-in-white, exhaust and mirror systems to both, three and four-wheeler OEMs. The study was conducted in the Purchase & Quality Department during an on-the-job-training period of 15th May to 15th July 2026 and the inventory data was analysed for the period of April to June 2026. It is for two production lines, M110 (C110) and W610.

B. Data and Research Design

The design is descriptive and solution-focused: The as-is process is identified in a quantitative way and a to-be process is created based on the results. A census was conducted rather than a sample as all 143 child parts and all 15 supply sources (including in-house production) in operation in the period was included. The four internal sources were merged: the master part list (part, line, supplier, bill-of-material quantity), the daily stock-tracking sheet (physical stock, line stock, days of coverage), the master of supplier and lead-time, and quality-issue register (defect type, responsibility, red - yellow - green status). Coverage records were complete for 140 of 143 parts and were not estimated for those without complete coverage records (because parts were added or discontinued during parts of the quarter). The records [14] have been supplemented by direct observation of daily practice and the sector figures are derived from public industry sources [1].

C. The Existing Process

Material flows from supplier to production planning, dispatch, store, physical stock and line stock. During routine counting, coverage is verified, and if it is low, a buyer will reach out to the supplier via telephone or messaging/e-mail. No step is system timed or logged. The seven weaknesses identified were: manual tracking, dependence on repeated manual follow-up; no central picture of stock and supplier; late communication of problems from suppliers; no comparison of coverage with lead time; no digital shortage register; quality handled separately from stock; and informally and untimed escalation.

A cause-effect analysis of the causes of shortage was made, and the causes were grouped under supplier, machine, material, method and manpower, communication causes being the most prominent, according to the process-level weaknesses. The machine category is illustrated by a die breakdown on a supplier in June 2026 that the author attended as part of a supplier visit and which was too significant to be viewed as a normal dispatch delay.

IV. PROPOSED FRAMEWORK (SIAD)

A. Architecture and Modules

Fig. 1 shows the framework. Purchase Department maintains a shared database, each supplier logs on securely and only sees parts for that supplier. Five modules are suggested. M1 Inventory Tracking records physical stock and line stock, updates stock upon QR-code scan at goods receipt and calculates coverage (2). M2 Supplier Portal displays supplier schedule, raw material availability/shortness, production

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start/finished, dispatched, transport delay, power cut and die breakdown status for each supplier. M3 Smart Alert System triggers alerts, reminders and escalations to thresholds. M4 Quality Feedback tracks supplier-wise remarks, defect history and red–yellow–green corrective-action separately. M5 Purchase Dashboard brings together other vital aspects of the purchase including parts, coverage, supplier status, lead-time alerts, quality issues and dispatch status into one view. There are five entities required in the data model: part master, supplier master, daily stock record, quality-issue record and alert log.

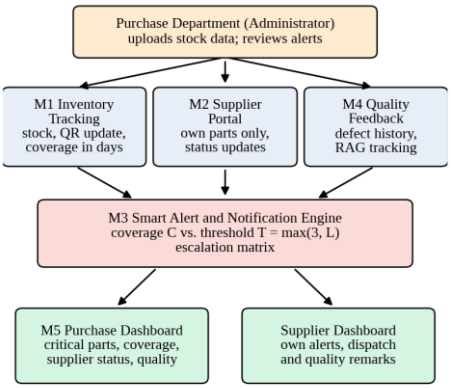


Fig. 1. Architecture of the proposed Smart Supplier Visibility and Inventory Tracking Framework (SIAD). *C*: coverage in days; *T*: alert threshold; *L*: supplier lead time.

B. Lead-Time-Adjusted Alert Rule

Existing practice uses a flat 3-day minimum. SIAD raises an alert for part *i*, supplied by source *s*(*i*), when

$$T_i = \max(T_0, L_{s(i)}) \quad (3)$$

$$C_i < T_i \quad (4)$$

The more conservative of the two is used, with $T_0 = 3$ and $L_{s(i)}$ the source's lead time in days. The thresholds obtained are shown in Table I. The rule applies only to the 10-day source, but here is the important thing: each of its four parts is included in W610, and the mean number of days covered by W610 was 5–6 days (Section V) compared to the lead time. The base threshold and the rule are initial values to be tuned on some extended history, like the safety-stock logic of (1).

TABLE I
LEAD TIME AND ALERT THRESHOLD BY SUPPLY SOURCE

Supply source (parts)	*L* (days)	Priority	*T* (days)
Fastnex OVT. Ltd. (4)	10	High	10
Sumit Precision Fasteners (3)	3	Medium	3
Kiran Fasteners (3)	2	Medium	3
Other 12 sources (133)	1	Normal	3

C. Escalation and Workflow

The proposed escalation matrix is followed by three alert levels. Level 1 (less than 72 hours coverage) is sent to the purchase officer the same work day, Level 2 (no supplier confirmation within 4 hours) is sent to the Purchase & Quality Head within 4 hours, Level 3 (confirmed shortage risk, less than 1 day coverage) is sent to the Plant Head immediately. The newly logged defect (status red) is directed to the Quality Engineer, immediately, the same working day as it is logged and if the issue is still red when the target closure date is reached, it is directed to the Purchase & Quality Head within 2 working days.

When used, the data is uploaded or scanned into the Stock File, the coverage is calculated and compared to Ti, and alerts are sent to the Purchase Department and the supplier. The supplier updates its status, the dashboard reflects the response in real time and quality comments are only visible for the supplier in question. SIAD assumes that suppliers can provide an update to a Web portal every day, and that the counts are reasonably accurate. For suppliers with limited connectivity, a simple messaging interface may be required. It can't stop a die breakdown or a raw-material shortage, but it can make time to detect and respond.

V. RESULTS AND DISCUSSION

A. Part and Supplier Distribution

W610 is made of 76 child parts (53% of the total number), M110/C110 was made of 67 child parts (47% of the total number), thus W610 requires a higher monitoring and coordination level of suppliers. A few suppliers account for the bulk of the supply for the 48 parts supplied (34%) of this top 5 – with Nexgen Precision Works LLP having the biggest share with 17 parts, followed by Ranjangaon with 17, and Vision Tools & Technology and V K Tools at 14 each. There are 37 parts available from the other ten sources. In ABC logic, the top 5 are the obvious first candidates for onboarding on the portal, but even a single-part supplier can put the brakes on the line.

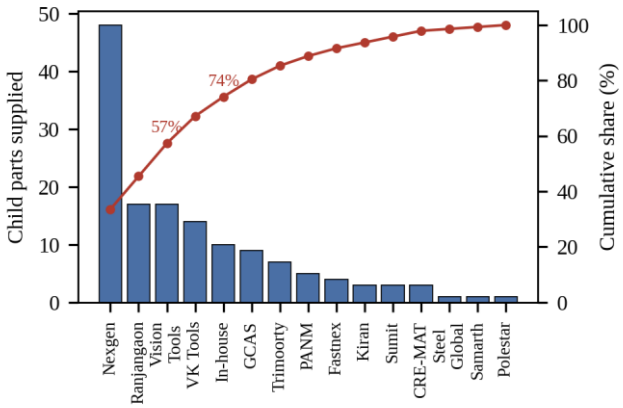


Fig. 2. Child parts supplied by each source and cumulative share of the 143 parts.

B. Inventory Coverage

Average coverage on M110/C110 was about 7, 8 and 7 days in April, May and June 2026, against about 5, 6 and 5 days on W610 (Fig. 3). Both lines were above the 3-day minimum, May was the best month for both and W610 was consistently tight. W610 is also more complex with more parts, which means that there is a higher exposure if there is a supplier delay or quality issue.

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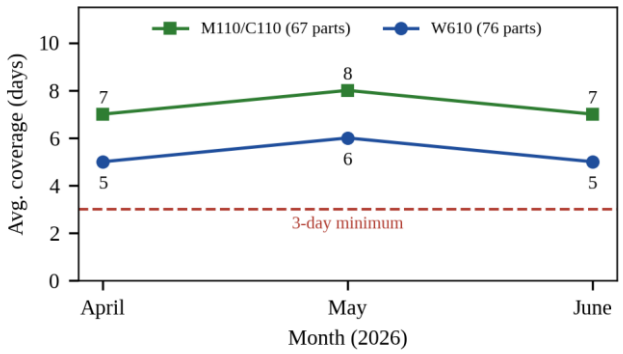


Fig. 3. Monthly average inventory coverage by production line, April–June 2026.

C. Supplier Lead Time

Fastnex OVT. The "days" in table I represent the average days Lead Time required for different sources with an average of 1 day for all other sources with Kiran Fasteners and Sumit Precision Fasteners as 2 days and 3 days respectively and Ltd. as 10 days. The average coverage of W610 was 5-6 days which is below the lead time of Fastnex. Where the parts act like the line average (like not reporting the part-level here), an order placed at this level will come in after they're out of stock, and this is a problem a 3-day flat rule can't solve. This aids in the lead-time adjusted threshold as in (3).

D. Shortage Frequency

Mean coverage was slightly above minimum (about 7.0 days) for the 140 parts that had complete April-June records. Things are different at part level: 91 parts (65%) were below 3 days on seven or more days, 38 parts (27%) on one to six days, and 11 parts (8%) on no days. So, a quarterly average coverage report obscures the reality of a substantial percentage of parts being in a critical condition during much of the quarter. This is the best evidence-based justification for part-based, ongoing alerts (M3).

E. Quality Issues

There are 60 quality problems in the Register. Of these, 45 were attributed to external suppliers (Nexgen 21, Vision Tools 13, GCAS Technology 7, V K Tools 2, CRE-MAT 1, Polestar 1) and 15 (25%) to internal causes at the plant and at its tool room/tool design. The 15 issues against Ranjangaon that are listed at the register are also this total. For each of the 77 defect observations, the defect is classified (Fig. 4a), with burr being the most common defect type (18, 23%), fitment issue (12, 16%), slot missing (10, 13%) and hole mismatch (9, 12%). Corrective-action status is poor (Fig. 4b): 43 issues (72%) are red, 11 (18%) yellow and only 6 (10%) green. This indicates that the corrective actions are not followed up to closure and that quality improvement is not a job for the suppliers.

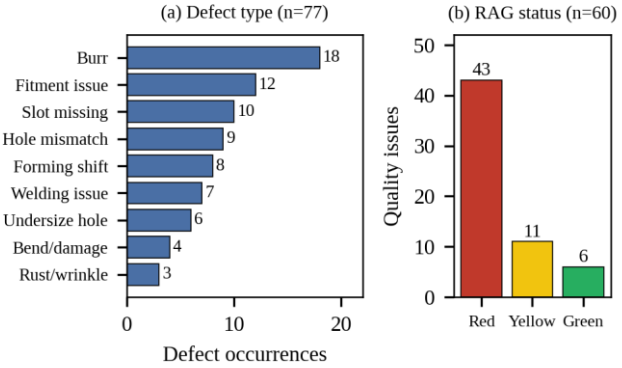


Fig. 4. Quality issues: (a) defect observations by type; (b) corrective-action status (red–yellow–green).

F. Discussion

The design is based on four findings. Part-level risk is not captured in the averages and must be alerted on the part level instead of periodically (M3). Second, supply is centralised, so the portal (M2) should include the most abundant and most faulty. Third, there is a wide range of lead times, warranting a lead-time dependent threshold. Fourth, corrective actions are not typically closed and one in four defects is internally attributed, meaning that M4 will need to follow up on any issues both from suppliers and internally and be able to show aging. These are consistent with the visibility literature [3]–[5] which relates to reactive decisions with late and incomplete information and are reported for one plant and one quarter only and should be interpreted with this caveat.

VI. IMPLEMENTATION IMPLICATIONS

The actions are listed in order in Table II. The pilot should be on the higher difficulty level of W610, having more parts and a tighter coverage; and the four high-priority sources (Nexgen, Fastnex, Ranjangaon, and Vision Tools & Technology). Since benefits are expected to be measured rather than observed, the pilot should gather before and after data on: (i) the portion of days that have $C_i < T_i$; (ii) the time that it takes from a breach to supplier affirmation; (iii) the percentage of quality issues that are closed within the target; and (iv) the percentage of production time lost due to shortages.

TABLE II
RECOMMENDED ACTIONS, PRIORITY AND TIMEFRAME

Action	Priority	Timeframe
Pilot Smart Alert System on W610	High	0–3 months
Lead-time-adjusted thresholds	High	0–3 months
Phased Supplier Portal (top four sources first)	High	3–6 months
Red–yellow–green quality tracking (M4)	Medium	3–6 months
Monthly supplier KPI scorecards	Medium	3–6 months
QR-code scanning at goods receipt	Medium	6–9 months
ERP (SAP) integration	Low (IT roadmap)	9–12 months

VII. LIMITATIONS AND FUTURE WORK

Case is done for one plant, one production line and only a 3 month period, so it is not tested for seasonal effects or generalizability. SIAD is a conceptual design, which has not

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been created or tested, and its benefits are estimated based on the data patterns. Defects are not recorded if they are unlogged or informally resolved, and also cannot be confirmed by supplier-reported causes of delay (raw-material shortage, power cut). The literature review is selective rather than systematic.

Future research needs to include: (i) developing the SIAD with before/after measurement, (ii) integration with the ERP system, (iii) the inclusion of mobile and dashboard tools, (iv) testing predictive models for raw material and other plant shortage and safety stock, and (v) comparing results between plants and industries, ideally with a systematic literature review.

VIII. CONCLUSION

The evidence from this plant indicates that child-part shortage exposure is less related to low average stock than to weak, incomplete and late visibility. While the mean coverage was approximately 7 days, 65% of parts had less than 3 days coverage, supply was sparse and limited to a few sources, one source's lead time of 10 days was above the average for W610's coverage, and only 10% of quality issues were resolved. SIAD responds to these results with part-level, lead-time aware alerts, supplier-focused visibility, built-in quality monitoring and a staged roadmap. This is a value that now needs to be tested in a pilot.

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