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Production Planning and Supply Chain Collaboration in Selected Polymer Manufacturing Firms: Inputs to Action Plan

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ABSTRACT

This study assesses the relationship between internal production planning practices and external supply chain collaboration within selected polymer manufacturing firms in Laguna and Quezon City. Anchored on Ludwig von Bertalanffy's General Systems Theory and Jay Barney's Resource-Based Theory, the research evaluates operational dynamics across twelve metrics using data collected from 150 purposively sampled respondents, including managers, operational staff, and supply chain partners. Methodological rigor was enhanced via expert validation of the instrument, internal reliability testing, and comprehensive statistical assumption verification. The empirical findings indicate that production planning practices are positively associated with enhanced supply chain collaboration, with batch size optimization yielding the highest operational mean. Analysis of variance (ANOVA) reveals significant perceptual variations among stakeholder groups regarding localized shop-floor mechanics such as lead time reduction, batch sizing, and Just-In-Time execution, highlighting critical coordination boundaries. Pearson product-moment correlation analysis demonstrates strong, positive linear associations across all collaborative dimensions. The article outlines structural limitations, provides theoretical insights for smart material governance under the Extended Producer Responsibility (EPR) Act of 2022, and defines strategic action horizons for future multi-method research.

INTRODUCTION

In the modern industrial landscape, manufacturing organizations operate within highly interconnected and volatile micro-environments. The polymer manufacturing sector represents a capital-intensive industry characterized by continuous-flow processing, rigid thermal baselines, and strict raw input requirements, making operational precision paramount. Organizations face intensifying pressure to navigate market fluctuations, mitigate structural disruptions, and comply with strict national environmental legislation, most notably the Extended Producer Responsibility (EPR) Act of 2022 (Republic Act No. 11898). This regulatory shift converts environmental stewardship from an isolated compliance function into a core production planning and logistics mandate, requiring a closed-loop flow of goods and highly integrated inter-firm coordination structures.

To maintain operational resilience under these conditions, firms must optimize the connection between two primary operational domains: internal Production Planning and external Supply Chain Collaboration. Historically, industrial research has frequently segregated these domains, treating scheduling as a localized engineering challenge and supply chain management as a transactional procurement activity. This siloed approach creates severe vulnerability to the bullwhip effect, where minor demand errors accumulate across departmental boundaries, resulting in mismatched schedules, unplanned downtime, and bloated inventory overhead.

In the Philippine domestic polymer market, which competes with large-scale international resin imports, establishing structural synergy between internal capacity allocations and external supplier networks serves as a vital financial and competitive lever. This study addresses these empirical gaps by investigating the prevailing practices of major manufacturing entities within the country's principal commercial hubs (Laguna and Quezon City). Specifically, it examines internal operational efficiency across dimensions of demand forecasting accuracy, capacity scheduling, lead time reduction, batch size optimization, resource allocation, and Just-In-

Time (JIT) application, while simultaneously mapping collaborative dimensions including vendor communication systems, performance evaluation protocols, information sharing, joint problem solving, and logistics synchronization.

THEORETICAL FRAMEWORK

The conceptual foundation of this investigation is built upon the synthesis of two complementary management frameworks: General Systems Theory (GST) and the Resource-Based Theory (RBT). General Systems Theory, pioneered by Ludwig von Bertalanffy (1968), posits that an organization functions as an open system composed of highly dependent, interacting subsystems that must maintain internal equilibrium while responding to external regulatory inputs. Under this view, production planning cannot operate in isolation; a disruption in inventory tracking or a failure in demand forecasting directly affects the processing rhythm of the factory floor and de-synchronizes supplier dispatch waves. Consequently, the whole is greater than the sum of its independent components.

Conversely, the Resource-Based Theory, popularized by Jay Barney (1991), focuses on the strategic cultivation of internal capabilities that are valuable, rare, imperfectly inimitable, and non-substitutable (VRIN). In capital-heavy polymer processing, generic assets like physical machinery or virgin feedstock are widely accessible across the competitive landscape. True competitive advantage is instead derived from non-material organizational capabilities, such as advanced data-driven scheduling algorithms, deeply embedded supplier trust mechanisms, synchronized multi-objective logistics protocols, and specialized workforce training. By combining GST and RBT, this study evaluates how internal planning disciplines interact with external relationship architectures to construct a unified dynamic capability.

METHODOLOGY

Research Design and Stakeholder Scoping

This study utilized a descriptive-correlational quantitative research design to document existing industrial practices and measure the linear associations between internal manufacturing scheduling and external collaboration without active experimental manipulation. The target population encompassed key professional stakeholders actively engaged in the operational lifecycle of six major polymer entities operating in Laguna and Quezon City: D&L Polymer and Colours, First in Colours, Manly Plastics, Inc., Sentinel, Triton, and United Polyresins. A non-probability purposive sampling approach was deliberately implemented to secure data exclusively from specialized key informants, such as plant managers, procurement officers, logistics leads, warehouse supervisors, and external distribution representatives. These individuals possess the technical exposure necessary to evaluate inter-firm systems accurately, maintaining a structured proportional representation across all six operations environments.

Instrument Development, Validation, and Reliability Testing

The primary research instrument consisted of a structured, five-part survey questionnaire engineered based on exhaustive operational literature and smart manufacturing frameworks. To ensure content validity, the initial draft was subjected to formal panel evaluation by an independent board of five industrial engineering and operations management experts. The expert panel quantified item relevance using a Content Validity Index (CVI), yielding a score of 0.92, which exceeds acceptable psychometric thresholds. Following content refinement, a pilot test was conducted with 15 non-participating manufacturing practitioners to evaluate structural clarity and internal consistency. Cronbach's α coefficients were calculated for each operational construct, demonstrating strong internal reliability: Demand Forecasting Accuracy ($\alpha = 0.86$), Capacity Planning ($\alpha = 0.88$), Lead Time Reduction ($\alpha = 0.84$), Batch Size Optimization ($\alpha = 0.89$), JIT Production Use ($\alpha = 0.85$), Resource Allocation Efficiency ($\alpha = 0.87$), Vendor Communication Systems ($\alpha = 0.91$), Supplier Performance Evaluation ($\alpha = 0.93$), Information Sharing Protocols ($\alpha = 0.88$), Joint Problem Solving ($\alpha = 0.90$), Logistics Synchronization ($\alpha = 0.85$), and Strategic Partnerships ($\alpha = 0.92$).

Data Collection and Statistical Assumption Testing

Data collection was completed synchronously over a two-month period from February to March 2026 utilizing secure web-based reporting portals to ensure asynchronous accessibility across distinct corporate facilities. A total of 165 questionnaires were digitally distributed, resulting in 150 fully completed, verified responses—a 90.9% response rate. The final respondent base comprised 25 managers (16.67%), 104 employees (69.33%), and 21 suppliers (14.00%). Prior to executing primary inferential tests, the raw data underwent diagnostic evaluation to ensure compliance with parametric statistical assumptions. Normality was verified via the Shapiro-Wilk test, indicating that the item distributions across the five-point Likert scale did not deviate significantly from normality ($p > 0.05$). Linearity between the independent and dependent dimensions was confirmed through matrix scatterplot checks. Homoscedasticity of variance across the three respondent groups was substantiated using Levene's test across all dimensions, yielding non-significant values ($p > 0.05$) and confirming the appropriateness of One-Way Analysis of Variance (ANOVA) and Pearson product-moment correlation (r).

RESULTS AND DISCUSSION

Descriptive Assessment of Production Planning Systems

The composite descriptive analysis demonstrates a highly functional baseline across the participating firms. The overall assessment for production planning yielded a grand mean of 3.99, verbally interpreted as Evident. This indicates that polymer firms maintain structured operational frameworks to schedule machinery and monitor material flows.

Operational Dimension	**Managers (WM)**	**Employees (WM)**	**Suppliers (WM)**	**Composite Mean**	**Verbal Interpretation**
Batch Size Optimization	3.92	3.98	4.17	4.02	Evident
Lead Time Reduction	3.93	3.92	4.17	4.01	Evident
Capacity Planning	3.92	3.97	4.13	4.00	Evident
Resource Allocation Efficiency	3.90	3.98	4.12	4.00	Evident
Demand Forecasting Accuracy	3.86	4.00	4.10	3.98	Evident
Just-In-Time (JIT) Production	3.59	3.94	4.20	3.91	Evident
Grand Mean	**3.85**	**3.97**	**4.15**	**3.99**	**Evident**

Batch size optimization obtained the highest composite rating (4.02), highlighting the industry's focus on maximizing machine efficiency and minimizing process changeover times. Because polymer machines operate under continuous high-temperature and high-pressure settings, even minor scheduling misalignments cause costly material purging intervals and extensive cleaning, making fixed sizing critical. Conversely, JIT production use obtained the lowest ranking (3.91), revealing a critical strategic vulnerability. While external suppliers rate the physical pull-based system highly (4.20), internal managers provide a significantly lower baseline (3.59), reflecting an operational gap where workforce readiness and internal execution lag behind external logistics networks.

Descriptive Assessment of Supply Chain Collaboration Frameworks

External collaborative networks generated a grand mean of 4.10, verbally interpreted as Evident. This confirms that participating firms actively maintain integrated communication networks and shared logistics structures to manage inter-firm interactions.

Collaborative Dimension	**Managers (WM)**	**Employees (WM)**	**Suppliers (WM)**	**Composite Mean**	**Verbal Interpretation**
Supplier Performance Evaluation	4.20	4.04	4.42	4.22	Highly Evident
Information Sharing Protocols	4.15	4.01	4.26	4.14	Evident

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Strategic Supplier Partnerships	4.16	3.98	4.27	4.13	Evident
Vendor Communication Systems	4.08	4.03	4.23	4.11	Evident
Joint Problem Solving	4.02	3.92	4.30	4.08	Evident
Logistics Synchronization	3.72	3.84	4.18	3.91	Evident
Grand Mean	**4.06**	**3.97**	**4.28**	**4.10**	**Evident**

Supplier Performance Evaluation scored highest (4.22, Highly Evident), indicating a disciplined and structured approach to tracking vendor accountability. However, a critical gap is revealed as joint metric reviews and integrated systems sit at the bottom of the sub-indicators. The evaluation framework functions primarily as an internal reactive checklist rather than a real-time collaborative tool. Logistics Synchronization obtained the lowest mean (3.91), showing that despite formal relationships, real-time coordination with regional transport and customs networks remains vulnerable to localized delays.

Inferential Analysis and Perceptual Variations

To analyze whether stakeholder assessments varied significantly based on organizational roles, a One-Way Analysis of Variance (ANOVA) was executed at an $\alpha = 0.05$ significance level. The findings reveal significant differences within the domains of localized execution, requiring refined data interfaces.

Operational Construct	**Between-Group MS**	**Within-Group MS**	**df**	**Computed F**	**Critical F**	**Statistical Decision**
Demand Forecasting Accuracy	0.015	0.021	2, 147	0.719	3.47	Fail to Reject Ho (Not Sig)
Capacity Planning	0.012	0.005	2, 147	2.322	3.47	Fail to Reject Ho (Not Sig)
Lead Time Reduction	0.020	0.004	2, 147	4.929	3.47	Reject Ho (Significant)
Batch Size Optimization	0.017	0.003	2, 147	5.849	3.47	Reject Ho (Significant)
Just-In-Time (JIT) Production	0.093	0.020	2, 147	4.547	3.47	Reject Ho (Significant)
Resource Allocation Efficiency	0.013	0.005	2, 147	2.392	3.47	Fail to Reject Ho (Not Sig)

The analysis reveals no significant differences regarding high-level strategic functions like demand forecasting, capacity planning, and resource allocation. This indicates cross-organizational alignment on broader targets. However, significant differences are observed within the domains of lead time reduction ($F = 4.929$), batch size optimization ($F = 5.849$), and JIT production use ($F = 4.547$). This statistical variance reveals a clear conflict in localized shop-floor execution. Frontline staff focus heavily on day-to-day tooling constraints and process disruptions, managers track high-level software milestones, and external suppliers operate based on gate arrival timelines, highlighting the need for unified data interfaces.

Correlational Analysis and Cross-Study Evaluation

To evaluate the mathematical relationship between the independent and dependent fields, Pearson correlation coefficients were calculated. The results demonstrate strong, positive linear associations across all collaborative metrics.

Collaborative Indicator	**r-value**	**Interpretation**	**df**	**t-value**	**Critical value**	**Statistical Decision**
Vendor Communication Systems	0.99	Very Strong Correlation	148	3.7412	2.145	Reject Ho (Significant)

Supplier Performance Evaluation	1.00	Perfect Correlation	148	3.7416	2.145	Reject Ho (Significant)
Information Sharing Protocols	0.99	Very Strong Correlation	148	3.7415	2.145	Reject Ho (Significant)
Joint Problem Solving	0.99	Very Strong Correlation	148	3.7414	2.145	Reject Ho (Significant)
Logistics Synchronization	0.99	Very Strong Correlation	148	3.7414	2.145	Reject Ho (Significant)
Strategic Supplier Partnerships	0.99	Very Strong Correlation	148	3.7411	2.145	Reject Ho (Significant)

These findings show that robust internal planning disciplines share a strong statistical relationship with heightened external collaboration. This strong connection matches recent international findings. On a global scale, Sagheer and Ahmed (2024) observed that digital tool integration exhibits a strong linear association with bullwhip reduction and agile information flow. This relationship is supported by Liu et al. (2021), whose investigation of enterprise resource planning networks demonstrated that end-to-end data visibility acts as a vital buffer against macroeconomic shocks and feedstock variations. Similarly, the structural trade-offs mapped by Taylor et al. (2025) match the local priority placed on batch size optimization, proving that dynamic, multi-objective scheduling protocols are positively associated with structural cost control.

However, local application faces unique challenges that diverge from Western or regional automated contexts. As documented by Shrestha (2021) via the World Bank, the Philippine recycling infrastructure is highly fragmented, suffering from high contamination baselines and a distinct lack of regional stakeholder coordination. Consequently, while local firms are pressured by the EPR Law of 2022 to implement closed-loop systems, they are frequently forced to bypass domestic markets and rely on imported virgin resins due to supply unreliability. This mismatch confirms that achieving true circular economy metrics requires moving beyond transactional contracting and adopting the long-term relational investments championed by Mendoza et al. (2024).

Study Limitations

The study focused on the selected polymer manufacturing firms in Laguna and Quezon City on the assessment of Production Planning in terms of demand forecasting, capacity planning, lead time reduction, batch size optimization, JIT production, and resource allocation. It also examines the extent of Supply Chain Collaboration, including information sharing, joint decision-making, strategic supplier partnerships, and supplier performance evaluation, respondents of the study as the challenges encountered and the acceptability of the proposed action plan.

The respondents of the study included a total of 150 participants, consisting of 129 internal stakeholders 25 Managers, 104 Employees and 21 Suppliers of the selected polymer manufacturing firms operating in the Philippines. The selection of these firms was based on their shared intercompany framework and operational prominence within the local polymer industry.

The study was conducted in the selected manufacturing firms in Laguna and Quezon City, specifically involving the departments of Procurement, Production, Warehouse, and Sales and Marketing.

The study was limited to stakeholders who were actively involved in the production and supply chain processes of the selected firms at the time of the survey. To ensure efficiency and maintain a streamlined process, the survey was conducted online via Google Forms, allowing for asynchronous data collection across the identified departments and supply partners.

Data collection and related activities were conducted over a specific period, beginning in February 2026 and concluding in March 2026.

CONCLUSIONS AND FUTURE DIRECTIONS

Conclusions

Based on the findings, the following conclusions are drawn:

1. The production planning of the firm is evident in terms of batch size optimization, lead time reduction, capacity planning, resource allocation, and demand forecasting.
2. There is a mixed result regarding the significant difference in assessments. While groups are aligned on forecasting and capacity, significant differences in perception regarding lead time, batch size, and JIT suggest a need for better internal and external alignment.
3. Supply chain collaboration practices are evident, particularly in supplier performance evaluation, which is highly evident.
4. There is a significant and very strong to perfect relationship between production planning and supply chain collaboration.
5. The respondents encountered both systems face moderate challenges. These include long production leads, inaccurate forecasts, inadequate communication systems, and poor logistics synchronization, indicating critical areas for intervention.
6. The proposed improvement plan is appropriate and responsive to the identified gaps, as it is anchored on key operational areas and supported by structured strategies and measurable indicators.
7. The proposed Action Plan is favorable among managers, employees, and suppliers, indicating it is feasible, practical, and supported by all stakeholders.

RECOMMENDATIONS

From the findings and conclusions of the study, the following are hereby recommended:

1. The organization may continuously enhance its production planning by adopting digital tools or software to improve demand forecasting precision and batch size efficiency.
2. Management should improve communication and alignment between departments and suppliers regarding lead times and JIT practices to resolve the significant differences in perception.
3. The company may sustain supply chain collaboration performance evaluation systems and further integrate these results into long-term procurement and strategic partnership decisions.
4. The organization may prioritize the synchronization of logistics with production schedules to minimize excess inventory and prevent delivery delays.

On Challenges Encountered, the firm may address operational challenges by:

Production Planning

Long and inconsistent production leads. It is recommended to implement process improvements and standard operating procedures to ensure consistency in cycle times.

Inaccurate demand forecasts. The firm should utilize historical sales data and digital forecasting tools more effectively to reduce stockouts and excess inventory.

Limited production capacity. It is recommended to proactively plan for capacity expansion and maintain flexibility to adjust during peak demand periods.

Inefficient batch sizes. The organization should conduct regular cost-benefit analyses to optimize batch sizes based on volume and setup times.

Inconsistent JIT application. Employees should receive regular training on JIT principles to prevent material shortages and interruptions.

Ineffective resource allocation. Management should utilize real-time production data to better assign human resources and equipment.

Supply Chain Collaboration

Inadequate communication systems. It is recommended to invest in digital platforms that facilitate real-time communication with vendors.

Poor logistics synchronization. The firm should use technology to track shipments and align delivery schedules with manufacturing requirements.

Lack of regular performance evaluation. While rated highly, the organization should ensure evaluations always lead to corrective action plans for poor performers.

Absence of strong strategic partnerships. The firm should involve strategic suppliers earlier in production planning discussions to enhance reliability.

Limited information sharing. Standardized protocols for sharing demand and forecast data should be established to ensure data consistency.

Weak coordination in problem-solving. Cross-organizational teams should be formed to jointly analyze root causes of supply chain disruptions.

Management should implement the proposed Production and Supply Chain Enhancement Program, ensuring proper resource allocation and continuous monitoring of performance indicators.

Given its high acceptability, the organization is encouraged to fully adopt the Production and Supply Chain Enhancement Program and involve all stakeholders to ensure successful execution.

Future studies may explore the impact of specific digital transformation tools like Artificial Intelligence on demand forecasting and logistics synchronization within the supply chain.

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