



An Event Sequence Study on the Organizational Capability Changes of Manufacturing Engineering and Technical Teams

Wei Ming Tan

Department of Mechanical Engineering, National University of Singapore, Singapore 117576, Singapore

Jun Kai Lim

Department of Mechanical Engineering, National University of Singapore, Singapore 117576, Singapore

Siti Nur Aisyah Rahman

Department of Mechanical Engineering, National University of Singapore, Singapore 117576, Singapore

Abstract: *During equipment upgrades and process adjustments, changes in the organizational capability of manufacturing engineering and technical teams directly impact production efficiency. This study analyzes the temporal relationship between key organizational events and production performance, focusing on the process of organizational capability change. The study uses 30 months of organizational adjustment and project execution data from an equipment manufacturing company, with a sample containing 4,960 organizational event records and corresponding production cycle and rework rate indicators. Event sequence analysis is used to identify organizational adjustment stages and compare the differences in production performance before and after the adjustment. The results show that within 3 to 6 months after the organizational restructuring, the average production cycle of key processes shortens by 7.4%, and the rework rate decreases by approximately 9%. The study indicates that organizational capability changes have quantifiable stage characteristics.*

Keywords: *Manufacturing; Organizational capability; Event sequence analysis; Engineering team; Production efficiency*

1. Introduction

Manufacturing engineering teams operate in environments where equipment upgrades, process optimization, and system integration frequently occur in parallel. Such transitions rarely affect only technical parameters; they typically trigger a chain of organizational actions, including team restructuring, role reassignment, workflow redesign, and updates to coordination rules. Empirical research on manufacturing digitalization indicates that technological upgrading is commonly accompanied by organizational reconfiguration, and that performance consequences often unfold over time rather than appearing immediately after implementation [1,2]. Organizational theory similarly emphasizes that the timing, sequencing, and interdependence of events shape how teams adapt, stabilize, or temporarily lose efficiency, suggesting that capability should be conceptualized as a dynamic process rather than a fixed attribute [3]. Recent work on strategic human resource

governance further shows that structured, data-driven alignment between organizational adjustments and capability deployment enhances adaptive capacity in complex, technology-intensive settings [4]. These perspectives collectively indicate that production performance during manufacturing transitions cannot be fully understood without explicitly examining sequences of organizational events. In operations management and industrial engineering, event-based data have increasingly been used to analyze how manufacturing systems evolve. Process mining and event-log techniques allow researchers to reconstruct actual execution paths and link them to performance indicators such as throughput time, bottlenecks, and quality deviations [5,6]. Studies demonstrate that event sequences can reveal accumulation points of inefficiency and distinguish performance differences across process variants, which is particularly relevant for engineering teams coordinating complex production tasks during equipment replacement or process reconfiguration [7,8]. Methodological developments have also treated event streams as structured time series, enabling the detection of behavioral shifts and adjustment phases rather than relying solely on aggregated summaries [9]. However, most applications remain focused on operational process flows, while organizational adjustments at the team level—such as coordination redesign or responsibility reallocation—are less frequently modeled as structured event sequences. Research on organizational change and team adaptation provides additional insights into why structural interventions may produce delayed or uneven performance effects. Event-oriented studies show that disruptive or high-impact events can temporarily weaken coordination efficiency before adaptive routines emerge [10]. Empirical findings on team resilience indicate that role clarity, formalization, and membership stability influence whether organizational change translates into sustained performance improvement or short-term fluctuation [11,12]. Conceptual models of organizational adaptation describe capability development as a staged progression, in which performance responses appear gradually after structural adjustments [13]. These findings imply that changes within manufacturing engineering teams are likely to be reflected in production metrics with measurable time lags, particularly during periods of simultaneous technological and organizational transformation. Despite these advances, several gaps remain in the study of organizational change in manufacturing contexts. Many analyses rely on cross-sectional surveys or coarse temporal aggregation, limiting the ability to trace how specific organizational actions influence subsequent production outcomes [14,15]. Although event-sequence methods have progressed rapidly, their integration with operational indicators such as production cycle time and rework rate is still limited, especially in manufacturing environments characterized by continuous improvement initiatives [16,17]. Moreover, organizational adjustments within engineering teams are often treated as contextual background rather than as explicit, ordered sequences of events with distinct stages and lagged performance implications [18]. As a result, the dynamic linkage between discrete organizational interventions and time-indexed production performance remains insufficiently quantified. The present study addresses these limitations by examining organizational capability change in a manufacturing engineering team through event sequence analysis over a 30-month period. The dataset comprises 4,960 recorded organizational events linked to production cycle time and rework rate indicators. Organizational actions—including restructuring decisions, workflow updates, and coordination rule modifications—are modeled as ordered sequences, and adjustment stages are identified within these sequences. Performance differences before and after structural changes are evaluated with attention to lagged effects across subsequent months. By integrating event-sequence modeling with operational performance metrics, the study reconceptualizes organizational capability as a staged and measurable process embedded within technological transition cycles. This approach contributes to both theory and practice. Theoretically, it extends event-sequence analysis beyond process execution toward team-level organizational dynamics, demonstrating how structural adjustments interact with production

outcomes over time. It advances understanding of capability evolution by linking discrete organizational interventions to observable performance trajectories rather than to static performance averages. Methodologically, the study illustrates how fine-grained organizational event records can be aligned with time-indexed operational data to identify adjustment phases and delayed effects. Practically, the findings provide empirical support for timing and pacing decisions during equipment upgrades and process adjustments, offering evidence-based guidance for managing transitional periods in manufacturing engineering environments. By clarifying when and how organizational changes influence production indicators, the study informs more precise coordination strategies and supports sustained performance stability under conditions of continuous technological transformation.

1. Materials and Methods

2.1 Sample And Study Context

The analysis is based on organizational and operational records from a large equipment manufacturing enterprise observed over a continuous 30-month period. The dataset includes 4,960 documented organizational events related to engineering and technical teams engaged in equipment upgrades and process changes. These events cover team restructuring, role reassignment, coordination rule modification, and project governance adjustment. Operational performance indicators were matched by time and include production cycle time and rework rate for major manufacturing processes. The study focuses on engineering teams responsible for core production stages, characterized by stable product portfolios and standardized quality requirements. Records with missing timestamps or unmatched performance data were excluded to ensure temporal alignment.

2.2 Study Design And Comparison Framework

A quasi-experimental before–after design was used to assess performance changes associated with organizational adjustment. Organizational events were grouped into adjustment phases according to their timing and functional scope, with emphasis on the completion of structural changes such as team reorganization or responsibility redistribution. Periods following adjustment completion were treated as the exposure condition, while periods preceding adjustment served as the comparison condition. This design allows performance differences to be evaluated under largely stable production settings while reducing confounding from product mix or equipment configuration. The approach is appropriate for organizational studies where controlled experimentation is not feasible but detailed longitudinal records are available.

2.3 Measurement Procedures And Quality Control

Production cycle time was measured as the elapsed duration between the start and completion of predefined key process steps, as recorded by the manufacturing execution system. Rework rate was calculated as the share of output units requiring corrective processing within each observation period. Organizational event data were extracted from internal management systems and cross-checked with project documentation to confirm event type and timing. Quality control procedures included consistency checks across data sources, removal of duplicate records, and verification of extreme values against original operational logs. All indicators were standardized to monthly intervals to ensure comparability across datasets.

2.4 Data Processing And Model Specification

Event sequence analysis was applied to identify stages of organizational adjustment based on the order and concentration of events over time. Performance indicators were aggregated by stage and compared across periods. Relative performance change was calculated using the following expression:

$$\Delta P = \frac{P_{\text{after}} - P_{\text{before}}}{P_{\text{before}}} \times 100\%$$

where P_{before} and P_{after} represent average performance levels before and after adjustment completion. In addition, a fixed-effects regression model was used to estimate the association between adjustment stage and performance outcomes:

$$Y_t = \alpha + \beta A_t + \gamma X_t + \varepsilon_t,$$

where Y_t denotes production cycle time or rework rate, A_t indicates post-adjustment periods, X_t includes control variables such as workload intensity, and ε_t is the error term.

2.5 Robustness And Sensitivity Analysis

Several robustness checks were conducted to assess result stability. Alternative definitions of adjustment completion were tested by shifting the boundary between pre- and post-adjustment periods. Subsample analyses were performed across different production lines to examine potential heterogeneity. Additional models excluded periods with abnormal demand fluctuations to reduce the influence of external shocks. Consistent coefficient signs and similar effect magnitudes across specifications were taken as evidence of robustness.

2. Results and Discussion

3.1 Event-Sequence Structure And Adjustment Phases

The organizational event log showed a clear phase structure over the 30-month period. Event frequency increased during restructuring, role reassignment, and coordination-rule updates, and then declined after the new working arrangement became stable. Changes in production performance did not occur at the formal completion point of organizational adjustment. Instead, a short stabilization period preceded observable improvement. This delay is expected in engineering teams, where new decision paths and handoff rules require repeated production cycles to become reliable. A phase-based interpretation therefore helps distinguish periods dominated by organizational change from periods characterized by stable execution, which cannot be captured by simple before–after comparisons [19,20]. Fig.1. Process-mining framework view for structured stage analysis.

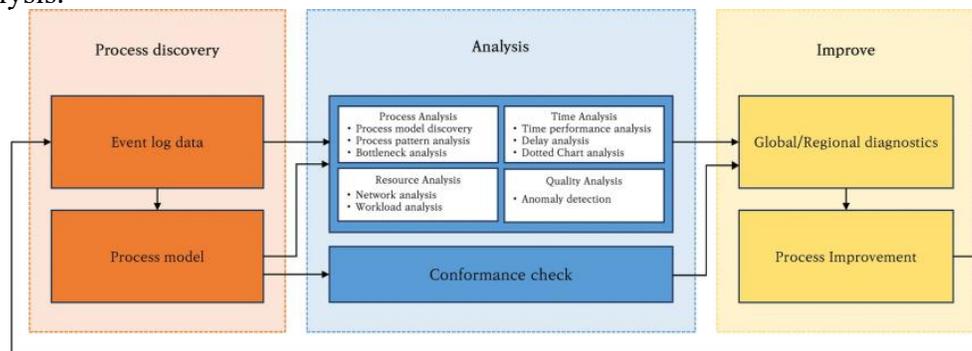


Fig.1. Process-mining framework used to identify adjustment phases in organizational event sequences.

3.2 Cycle-Time Gains After Restructuring Completion

Cycle time for key operations declined during the 3–6 months following restructuring completion, with an average reduction of 7.4%. The delayed timing indicates that the improvement resulted from more consistent execution rather than a temporary scheduling adjustment. In manufacturing systems, extended cycle times are often caused by waiting, repeated checks, and route changes that arise from unclear responsibility or slow escalation [21]. After restructuring, clearer role definitions and more direct coordination reduce these delays and shorten high-duration cases. Evidence from event-log studies similarly shows that cycle time changes as activity patterns stabilize, supporting a time-dependent interpretation of performance improvement [22]. Fig.2. Cycle times and productivity under initial versus updated cycle-time inputs.

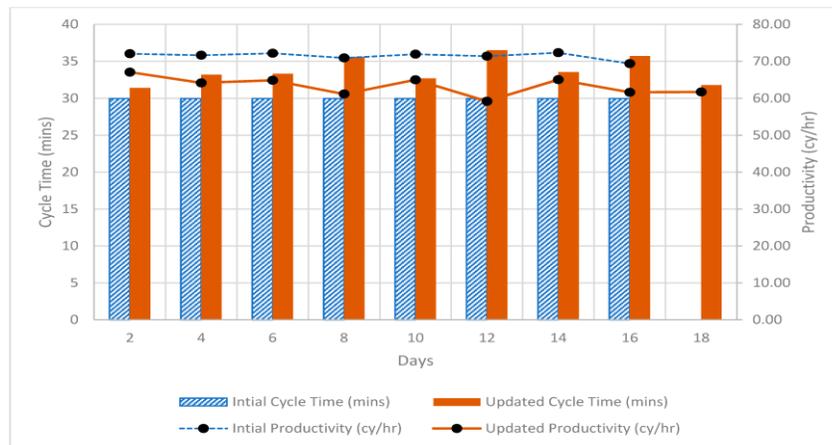


Fig.2. Changes in cycle time and productivity before and after organizational adjustment based on integrated process-mining and simulation analysis.

3.3 Rework Reduction And Delayed Quality Stabilization

Rework rate decreased by approximately 9% over the same 3–6 month period, indicating that quality improvement followed a gradual stabilization process. This pattern reflects a simple mechanism. Organizational restructuring first alters coordination roles and escalation paths, while defect reduction depends on repeated cycles of stable execution after responsibilities become clear [23]. During periods of frequent organizational change, temporary ambiguity in task ownership can increase the likelihood of missed checks or delayed detection of process deviation, even when equipment settings remain unchanged. Once event intensity decreases and routines become consistent, defects are identified earlier and resolved with fewer repeated corrections, leading to sustained quality improvement.

3.4 Comparison With Related Evidence And Operational Implications

Existing manufacturing studies often focus on process-flow analysis, while organizational adjustments are treated as contextual factors. The present results show that internal organizational actions can be analyzed as event sequences with measurable time-lagged effects on cycle time and rework. The staged response has practical importance. Performance assessments conducted immediately after restructuring are likely to underestimate its impact, whereas the 3–6 month window captures the period when coordination routines consolidate and benefits become visible. For operational planning, major restructuring should be scheduled with sufficient buffer before delivery-critical periods. Monitoring should consider efficiency and quality together to avoid improvements in throughput that are not supported by stable execution [24].

3. Conclusion

This study analyzes how organizational capability in manufacturing engineering teams develops through sequences of organizational adjustments and how these changes affect production performance over time. Using event sequence analysis on longitudinal organizational and operational data, the results show that reductions in cycle time and rework rate do not appear immediately after restructuring but become evident during a subsequent stabilization period, typically three to six months later. This pattern indicates that improvements depend on the gradual formation of stable coordination routines, clearer role allocation, and more consistent execution across repeated production cycles. The main contribution of this work is the use of event sequence analysis to capture organizational change as a time-ordered process rather than a single intervention, which allows a direct link between internal organizational dynamics and measurable operational outcomes. From a practical perspective, the findings support stage-aware management of engineering teams, suggesting that organizational restructuring should be planned with adequate

lead time before performance-critical phases and assessed using time-sensitive indicators instead of immediate post-change results. Some limitations should be acknowledged. The analysis relies on data from one manufacturing enterprise, which may restrict the general applicability of the findings, and external influences such as demand variation and individual learning effects could not be fully separated. Future studies could apply this framework to multi-enterprise datasets and incorporate more detailed behavioral or process-level data to further clarify how organizational capability stabilizes and improves in complex manufacturing systems.

References

- Gu, X., Yang, J., Tian, X., & Liu, M. (2025). Research on the Construction of a Human-Machine Collaborative Anti-Money Laundering System and Its Efficiency and Accuracy Enhancement in Suspicious Transaction Identification.
- Nour, S., & Arbussa, A. (2025). Driving innovation through organizational restructuring and integration of advanced digital technologies: a case study of a world-leading manufacturing company. *European Journal of Innovation Management*, 28(8), 3262-3283.
- Zhu, W., Yang, J., & Yao, Y. (2025). How Cross-Departmental Collaboration Structures Mitigate Cross-Border Compliance Risks: Network Causal Inference Based on ManpowerGroup's Staffing Projects.
- Li, T., Xia, J., Liu, S., & Hong, E. (2025). Strategic Human Resource Leadership in Global Biopharmaceutical Enterprises: Integrating HR Analytics and Cross-Cultural.
- Butt, N. A., Mahmood, Z., Sana, M. U., Díez, I. D. L. T., Galán, J. C., Brie, S., & Ashraf, I. (2023). Behavioral and performance analysis of a real-time case study event log: A process mining approach. *Applied sciences*, 13(7), 4145.
- Liu, S., Feng, H., & Liu, X. (2025). A Study on the Mechanism of Generative Design Tools' Impact on Visual Language Reconstruction: An Interactive Analysis of Semantic Mapping and User Cognition. *Authorea Preprints*.
- Kauf, C., Ivanova, A. A., Rambelli, G., Chersoni, E., She, J. S., Chowdhury, Z., ... & Lenci, A. (2023). Event knowledge in large language models: the gap between the impossible and the unlikely. *Cognitive Science*, 47(11), e13386.
- Sheu, J. B., & Gao, X. Q. (2014). Alliance or no alliance—Bargaining power in competing reverse supply chains. *European Journal of Operational Research*, 233(2), 313-325.
- Landauer, M., Skopik, F., Stojanović, B., Flatscher, A., & Ullrich, T. (2025). A review of time-series analysis for cyber security analytics: from intrusion detection to attack prediction. *International Journal of Information Security*, 24(1), 3.
- Wang, J., & Xiao, Y. (2025). Research on Transfer Learning and Algorithm Fairness Calibration in Cross-Market Credit Scoring.
- Nyamekye, S., & Kwarteng, A. H. (2025). Dynamic capabilities and factors contributing to business continuity in professional-service firms: evidence from law practice in an emerging economy. *Management Research Quarterly*, 2(2), 23-37.
- Gu, X., Yang, J., & Liu, M. (2025). Research on a Green Money Laundering Identification Framework and Risk Monitoring Mechanism Integrating Artificial Intelligence and Environmental Governance Data.
- Saputra, N., Putera, R. E., Zetra, A., Azwar, Valentina, T. R., & Mulia, R. A. (2024). Capacity building for organizational performance: A systematic review, conceptual framework, and future research directions. *Cogent Business & Management*, 11(1), 2434966.
- Du, Y. (2025). Research on Digital Quality Traceability System for Temperature-Controlled Supply Chain of Foreign Trade Wine Driven by Blockchain and IoT. *Business and Social Sciences Proceedings*, 4, 57-65.

- Ogbonnaya, C., Daniels, K., Messersmith, J., & Rofcanin, Y. (2023). A theory-based analysis of null causality between hr practices and outcomes: Evidence from four-wave longitudinal data. *Journal of Management Studies*, 60(6), 1448-1484.
- Mao, Y., Ma, X., & Li, J. (2025). Research on API Security Gateway and Data Access Control Model for Multi-Tenant Full-Stack Systems.
- Abbasi, M., Nishat, R. I., Bond, C., Graham-Knight, J. B., Lasserre, P., Lucet, Y., & Najjaran, H. (2025). A review of AI and machine learning contribution in business process management (process enhancement and process improvement approaches). *Business Process Management Journal*, 31(4), 1414-1452.
- Du, Y. (2025). Research on Deep Learning Models for Forecasting Cross-Border Trade Demand Driven by Multi-Source Time-Series Data. *Journal of Science, Innovation & Social Impact*, 1(2), 63-70.
- Huić, I., Kosec, P., Martinec, T., & Škec, S. (2026). Process Mining in Digital Dental Laboratories: Identifying Iterations Through Actions and Digital Artefacts.
- Zhu, W., Yang, J., & Yao, Y. (2025, October). How Compliance Maturity Translates to Risk Reduction: A Multi-Case Comparison of Global Operations Using fsQCA and Hierarchical Bayesian Methods. In *Proceedings of the 2025 2nd International Conference on Digital Economy and Computer Science* (pp. 672-676).
- Morandini, S., Fraboni, F., Hall, M., Quintana-Amate, S., & Pietrantoni, L. (2025). Human factors and emerging needs in aerospace manufacturing planning and scheduling. *Cognition, technology & work*, 27(1), 59-77.
- Wang, J., & Xiao, Y. (2025). Assessing the Spillover Effects of Marketing Promotions on Credit Risk in Consumer Finance: An Empirical Study Based on AB Testing and Causal Inference.
- Klotins, E., & Talbert-Goldstein, E. (2023, May). Organizational conflicts in the adoption of continuous software engineering. In *International Conference on Agile Software Development* (pp. 149-164). Cham: Springer Nature Switzerland.
- Shish, Z. H., & Shafa, H. (2023). A Quantitative Study On IT-Enabled ERP Systems And Their Role In Operational Efficiency. *International Journal of Scientific Interdisciplinary Research*, 4(4), 62-99.