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PERFORMANCE MEASUREMENT IN TAKT PRODUCTION: AN EXPLORATORY STUDY ON METRICS, PRACTICES AND CHALLENGES

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ABSTRACT

Takt production gained attention in construction as a lean planning and control method that synchronizes workflows and enables product continuous flow. However, limited research has addressed performance measurement in takt production. This paper aims to identify research gaps in takt performance measurement, based on core concepts related to takt production, and the need for mechanisms to cope with unexpected variability. Several metrics for measuring takt performance were identified in the literature, organized into seven categories. Three exploratory case-studies were conducted in Chile, USA, and Japan, chosen due to the context heterogeneity and takt production methods diversity. Data analysis revealed different takt performance measurement approaches across different contexts. Company A developed a performance measurement system based on a production status matrix, used for controlling WIP, cycle time variation, and batch completion. Company B implemented takt production within an Integrated Project Delivery framework, in which performance measurement was based on Last Planner® System metrics. Company C employed a type of takt production system based on daily progress reports. The findings highlight improvement opportunities for takt performance measurement, including exploring leading metrics related to intermediate takt production goals, extend takt production metrics to other processes, and devise metrics for supporting adaptive capacity.

KEYWORDS

Takt production, location-based planning and control, performance measurement systems, complexity, slack.

INTRODUCTION

Takt time is a fundamental element in production planning and control for Lean Production Systems. It enables the synchronization of production process, so that both continuous flow of

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products and uninterrupted flow of crews can be achieved (Formoso et al., 2025; Tommelein et al., 2024). It has been widely used in manufacturing for several decades. In recent years interest has grown in developing takt production approaches for different types of construction projects, including high-rise buildings, infrastructure, industrialized construction, etc. (Tommelein et al. 2024).

The overarching goals of takt production include reducing project duration and increasing plan reliability. These goals are supported by intermediate objectives, such as reducing batch sizes, eliminating rework, avoiding crew stacking, synchronizing workflows, simplifying control procedures, and improving transparency (Formoso et al., 2025). Although intermediate objectives are usually related to leading indicators, i.e., metrics driven by performance (Kaplan & Norton, 1992), a well-balanced Performance Measurement System (PMS) must have a combination of leading and lagging indicators, i.e., metrics driven by results (Kaplan & Norton, 1992) with the aim of identifying improvement opportunities at the operational and tactical levels and connecting them to strategic goals (Barth & Formoso 2024).

Despite the growing interest for takt production in construction, little attention has been paid to performance measurement for this type of planning and control method. Previous studies on the implementation of takt control refer to the use of set of isolated metrics that mostly emphasize strict adherence to plans, including punctuality in relation to planned start (or end) time in each takt area (Keskiniva et al., 2023; Lehtovaara et al., 2021), and production rate deviation (Vargas et al., 2023). The use of only this type of metric results from the adoption of an approach called “management by adhering”, which has been criticized by Koskela and Howell (2002), who suggested an alternative approach known as “management as learning” or “management as organizing”, based on the work of Johnston and Brennan (1996).

Devising PMSs is particularly challenging in construction projects, as these must be regarded as complex sociotechnical systems, characterized by both a large number of distinct parts that interact dynamically (Baccarini, 1996) and high variability in processes and goals (Williams, 1999). As in any complex system, it is important to have mechanisms to cope with a high degree of unexpected variability. Therefore, planning and control systems must have performance metrics that support the capacity to adapt in the case of emerging events. According to Hollnagel et al. (2017), adaptive capacity depends on four main capabilities: respond (knowing what to do), monitor (knowing what to look for), learn (knowing what has happened), and anticipate (knowing what to expect).

This paper presents an exploratory study on performance metrics used for takt production in construction. While the importance of metrics for managing takt production is widely acknowledged, their conceptualization, particularly regarding how to capture intermediate results of takt production, has not yet been articulated in the literature. Therefore, this study addresses the following research question: how takt performance measurement can be extended to assess the achievement of intermediate goals and support adjustments that are necessary due to the complex nature of construction projects? The aim of the paper is identifying research gaps in takt performance measurement, based on the explicit understanding of core concepts related to takt production, and also on the need to have mechanisms to cope with complexity.

This paper presents an exploratory study on takt performance measurement in construction, based on an extensive literature review on takt performance metrics and also on three case studies carried out in companies located in different countries: Chile, USA and Japan. Its main outcomes are (1) a set of categories for takt performance metrics extracted from the literature; (2) good practices on the use of takt performance metrics from the three companies; and (3) a discussion of the challenges of the implementation of takt performance metrics. The paper contributes to knowledge by presenting emerging concepts and identifying patterns to be applied in PMSs. This study builds on previous studies on the impact of project complexity in the design of takt production planning and control systems, which have been reported in previous IGLC conferences (Barth and Formoso, 2024; Tommelein et al, 2024; Formoso et al., 2025).

LITERATURE REVIEW

Formoso et al. (2025) developed a set of preliminary propositions for implementing takt control in construction projects, considering requirements of control systems designed to manage complexity. Some of them are directly related to the definition of takt performance metrics, such as: (i) control of work in progress based on a location-based system, (ii) early detection of deviations from takt plans, (iii) sharing information by using visual management, (iv) extend takt implementation to allow the early detection of quality failures, (v) apply pull production by controlling system status, (vi) promote improvement and learning, and (vii) use digital technologies to partially automate data collection and processing.

Building on Formoso et al. (2025), a comprehensive list of performance metrics was produced, based on empirical studies on this theme reported in the literature and also on theoretical studies related to production control. Those metrics were organized into categories, reflecting fundamental constructs for lean production performance (Ohno, 1988): (1) adherence to schedule, (2) flow performance, (3) work-in-progress (WIP), (4) planning reliability, (5) waste and quality, (6) continuous improvement, and (7) others (e.g., supply chain, slack).

Table 1 presents some examples of takt performance metrics described in the literature, related to each category. All categories are from lean production and lean construction literature, with some (e.g., adaptive capacity) influenced by the field of resilience engineering. Metrics marked with an asterisk (*) represent proposals based on conceptual studies rather than metrics that have been applied in practice. These metrics were included because they can provide ideas for extending the scope of takt performance measurement beyond the adherence to plans. For some of the identified metrics, related constructs have been explored in specific studies. For example, batch size has been discussed through the concepts of work density or production tightness (Lehtovaara et al., 2021; Tommelein, 2022). However, due to limitations of space, only a few representative metrics were selected to be presented for each construct.

Adherence to schedule and flow performance metrics (e.g., punctuality, lead-time deviation, percentage of uninterrupted workflow, re-entrant flow) are some of the most common metrics adopted in empirical studies (Keskiniva et al., 2023; Lehtovaara et al., 2020; 2021; Sacks et al., 2017). Some of these metrics are usually classified as lagging indicators as, if used in isolation, they are limited to traditional project-control logic. Some empirical studies have reported that plan reliability metrics related to the Last Planner® System (LPS), such as the PPC and constraint removal effectiveness, have been used as leading indicators for Takt Production. Although those metrics are relevant, they are not sufficient on their own, as they do not capture key flow-related aspects, such as batch size, WIP, and continuity of work.

WIP metrics capture the space-time coupling, central to takt flow and can be regarded as a key intermediary takt objective measurement and therefore can be used to produce leading indicators – the same logic is applicable to other types of metrics, such as continuous improvement, quality reliability, and material supply reliability (see Table 1). Leading metrics contribute to establish a production control approach beyond management as adhering, towards management as learning and organising (Koskela and Howell, 2002), improving the system’s ability to cope with complexity through resilience capabilities (Hamerski et al., 2024). Furthermore, the adoption of some metrics must be regarded as countermeasures, as suggested by Spear and Bowen (1999): the set of metrics used in takt production must be adapted dynamically as new sources of variation emerge, i.e., the set of metrics and the way they are produced must evolve as part of organisational learning.

RESEARCH METHOD

Multiple case studies were the research method adopted in this investigation, involving both intra- and cross-case analysis (Yin 2014). This method can produce knowledge about complex events while allowing comparison from real-life bounded systems (Eisenhardt 1989; Creswell 2013). Data was collected from three construction companies located in different continents: Chile (Case A), USA (Case B), and Japan (Case C). These case studies were selected due to: (i) opportunities for insights related to the application of takt production in different contexts; and (ii) offering of diverse and complementary ways to analyse takt performance metrics, as those companies have used different takt production methods based on Lean Construction. In Case Studies A and C the unit of analysis was the whole company, while in Case B only one construction project was analysed.

Company A is a leading company in Chile that develops and builds residential projects for lower-, middle-, and upper middle-class markets. At the time of the study, the company employed around 2,200 people and managed a portfolio of more than 100 residential projects, with annual sales exceeding 3,000 dwellings. In 2024, the company reported total revenues of approximately USD 442 million. This company was selected because of its engagement in a long-term Lean-based improvement program, in which LPS was implemented in all projects, combined with location-based planning and control. This company also developed and implemented a comprehensive PMS, involving several cycles of planning, incremental implementation, evaluation, and reflection (from February 2020 to September 2021).

Company B is a general contractor in the USA recognized for its large experience with Lean Construction, particularly in the implementation of Integrated Project Delivery (IPD). The case study was undertaken in a single project, a seven-story, 170,000-square-feet healthcare facility in California delivered under an IPD contract. The typical building layout included a Lower Level (below grade), a Mechanical Level (above grade), and five clinical floors (Levels 1–5). Construction started in 2023. This project was selected because takt production was implemented throughout the delivery phase, based on a takt-based planning methods developed by the company.

Company C is a leading design-build general contractor in Japan that operates in several segments of building construction, including office, commercial, and residential. In over 80% of its projects, integrated design-build is the delivery system adopted, in which design is undertaken by internal architectural, structural, and mechanical, electrical and plumbing (MEP) design departments. All on-site activities are carried out by subcontractors. This company was selected because it has used takt production practices (particularly in the high-rise residential segment) for several years, although the implementation of formal Lean Construction concepts is part of a more recent initiative.

Table 1: Takt performance metrics

Categories	Metrics or attributes to be measured	Definition	Key references
1. Adherence to schedule	1.1. Punctuality	Difference between actual and planned start (or end) times for each takt area.	Keskiniva et al. (2023)
	1.2. Lead time deviation	Extent to which actual lead time differs from expected or planned lead time for a project, activity, or wagon.	Keskiniva et al. (2023) Lehtovaara et al. (2021)
	1.3. Pace deviation	Difference between the interval of two adjacent takt areas and the planned takt time, reflecting process speed.	Lehtovaara et al. (2020)
2. Flow performance	2.1. Percentage of uninterrupted workflows	Percentage of workflow that proceeds without interruption according to the takt plan (can be from crews or product).	Brodetskaia et al. (2013) Sacks et al. (2017)
	2.2. Re-entrant flows	Percentage of activities requiring crews to return to the same location, either by design or due to defects.	Brodetskaia et al. (2013) Sacks et al. (2017)
	2.3. Percentage of synchronized processes	Number of processes synchronized by takt time divided by total number of processes.	Formoso et al. (2022); Vargas et al. (2023); Bataglin et al. (2022); Haugen et al. (2020)
3. Work-in-progress (WIP)	3.1. Takt zone overlap	Number of takt zones occupied simultaneously by the same trade or crew.	Keskiniva et al. (2023); Sacks et al. (2017)
	3.2. Cycle time variation	Difference between planned and actual cycle time; variation in time producing two successive units under stable conditions.	Formoso et al. (2025); Vargas et al. (2023)
	3.3. Batch size	Amount of work completed before being handed off to the next process.	Lehtovaara et al. (2021) Tommelein (2022)
4. Planning reliability	4.1. Percent plan complete (PPC)	Percentage of tasks completed out of the tasks planned for the short-term planning period	Ballard (2000); Ballard & Tommelein (2021)
	4.2. Constraints removal index	Percentage of planned tasks with all constraints removed within the look-ahead window.	Ballard (2000)
5. Waste and Quality	5.1. Percentage of value adding time or steps	Percentage of value-adding time activities (or steps) compared to total time (or steps) of a product flow.	Binninger et al. (2019); Lehtovaara et al. (2020); Dlouhy et al. (2016)
	5.2. Percentage of unfinished work-zones	Portion of incomplete work zones relative to the total, based on a status matrix.	Fireman et al. (2013)
	5.3. Rework rate	Percentage of work requiring correction/re-execution after initial completion, measured in time, cost or activities.	Ballard & Tommelein (2021); Lehtovaara et al. (2020)

Table 1: Takt performance metrics (continued)

Categories	Metrics or attributes to be measured	Definition	Key references
6. Continuous improvement	6.1. Continuous improvement events	Number of kaizen activities, gemba walks, A3 reports, and similar improvement actions.	Riekki et al. (2025)
	6.2. Continuous improvement benefits*	Number of tangible and intangible outcomes such as productivity improvement, quality improvement, lead-time reduction.	Ahonen et al. (2022)
	6.3. Adaptive capacity*	Measures how effectively the system adjusts to changes or disturbances while maintaining planned flow, performance, and stability.	Woods (2018)
7. Material supply	7.1. Inventory turn-over rate	Difference between materials delivered and materials consumed.	Riekki et al. (2025)
	7.2. Materials delivered according to takt time	Percentage of design or material deliverables completed and validated before each takt start.	Riekki et al. (2025) Lehtovaara et al. (2020) Lehtovaara et al. (2019)
8. Slack	8.1. Types of slack	Number of different types of planned slack (e.g., time buffers, capacity buffer, space, inventories, WIP, multi-functionality, confirmation points, contingency plans).	Formoso et al. (2021); Saurin et al. (2021)
	8.2. Consumption of slack*	Extent to which planned slack (time buffers, WIP, capacity buffers, inventory) is consumed during execution.	Formoso et al. (2021); Saurin et al. (2021)

FINDINGS

COMPANY A

The production planning and control system of Company A combined three methods. At the pre-construction phase a production system design was developed, which included the division of the project in batches, definition of the overall construction sequence, definition of resources and estimation of production capacity, definition of main workflows, design of site layout, as well as logistics plans, a location-based plan, and detail designs of critical processes. LPS was implemented by using three hierarchical levels: long-term, lookahead and weekly planning. All project long-term plans were produced as comprehensive location-based plans, strongly based on takt production, although including also non-repetitive tasks.

A matrix for controlling the production status in each work zone was used (see similar example in Sacks et al., 2009). This control was made possible by monitoring check-in and check-out of each crew in different work-zones, enabling to monitor the production status, identifying whether tasks are completed, in progress, stopped, or not started. The production status matrix can be regarded as a tool for pulling production, allowing work to be released “based on system status” rather than based on demand estimates (Hopp and Spearman, 2008). Several leading metrics were obtained from this matrix (Table 3). Traditional LPS metrics and adherence to plan metrics (batch adherence and pace deviation) were also used.

Table 2: Sources of evidence used in the three case studies

Company	Sources of Evidence
A	Participant observation Direct observation Individual and group interviews Analysis of performance measurement databases Analysis of existing software tools Analysis of documents: project reports, dashboards, presentations about performance measurement
B	Participant observation (weekly site meetings) Individual and group interviews (production managers, trade foremen during color-up meetings) Analysis of documents (project documents, drawings, takt plans produced in digital platforms)
C	Non-participant observation of office, hotel and residential projects Asynchronous meetings with project members Analysis of existing software tools (e.g., production planning and control) Analysis of documents (e.g., project plans, visual management devices, reports)

A PMS Group was formed, including representatives from different departments of the company. That team produced maps of strategic goals and actions for the company Lean implementation program. Based on those maps, the PMS was devised, including metrics, performance dashboards and continuous improvement initiatives. Pilot studies for the implementation of standardized work were developed for synchronizing workflows in takt plans.

Table 3: Leading metrics adopted by Company A

Metric	Definition
WIP control	Comparison between two project progress curves, one based on all activities (traditional earned value) and another considering only completed batches.
Cycle time variation	Cycle time for each batch was obtained by monitoring check-in and check-out. Variation of cycle time can be regarded as a measure of basic stability, as it may lead to the increase of work in progress.
Batch completion pace	The pace of batch completions was used for the early detection of problems in terms of keeping the pace of workflows similar to takt time. Projections of project durations were used to trigger takt recovery plans.

COMPANY B

The project's production planning system was based on the LPS, within which takt production was implemented. The production team defined initial zone breakdowns, phase sequences, and scope-specific takt trains (trade sequences moving zone-to-zone). Color-up sessions with trade partners were conducted in early project stages to develop the baseline takt plan, where project drawings were marked up to describe work sequences, crew sizes (e.g., increasing HVAC team capacity to mitigate bottlenecks), necessary overlaps (e.g., revealing unavoidable overlaps between mechanical and plumbing trades in shared ceiling zones), and different production rates (e.g., plumbing and medical gas can progress faster than mechanical piping). Weekly meetings on site were held to discuss sequence adjustment and crew size in order to adhere to the takt time. For overhead MEP, Company B implemented sub-phases to enable parallel trains with standardized process steps: hangers, racks, horizontal piping and ductwork, testing, and insulation. Takt durations ranged from 5 to 12 working days per zone with mechanical piping as the pacing trade. Typically, each floor was divided into four zones with similar area sizes (about 750 m^2). These lined up to some degree with architectural and structural layouts, but introduced workload imbalances to other scopes (e.g., one zone included major shafts and risers, so it had denser mechanical work than other zones).

The takt production performance was managed through two digital platforms: (1) Digital Platform A, which functioned as the central planning platform (e.g., supporting the master schedule, tracking milestone, and lookahead planning), being used by the owner; and (2) Digital Platform B, which was used by the general contractor for takt production to coordinate work across zones (e.g., as visual coordination with the trade partners). LPS metrics such as Percent Plan Complete (PPC) were tracked and displayed in the Big Room together with PPCO (Percent Promises Complete Overall), CL (Constraints Log), and PRCO (Percent Resolved Constraints Overall) (refer to Ballard and Tommelein, 2021 for definitions). With this approach, production control was emphasized through lookahead planning, weekly work planning and commitment management.

Some of the takt-production learning occurred through the ad-hoc color-up meeting (e.g., work density analysis). It allowed foremen to document lessons-learned in execution, which supported field-based validation of production assumptions and helped to surface insights (e.g., work sequences, crew sizing, necessary overlaps) to support production control. Table 4 presents metrics adopted by Company B.

Table 4. Metrics adopted by Company B

Metric	Definition
Plan reliability	PPC and PPCO to monitor weekly commitments, and constraints removal with CL (Constraints Log) and PRCO (Percent Resolved Constraints Overall) to monitor constraints within the look-ahead.
Visual management	Digital platforms for visual tracking and coordination, which shows where trains are, what is next, and where clashes or gaps are emerging. One of the digital platforms also supported reporting on handoff.
Continuous improvement	Continuous improvement through bottleneck and work density learning (e.g., color-up session), to reveal uneven workload distribution to inform planning improvement discussions.

COMPANY C

The production planning system in Company C adopts takt production elements in some projects, but it was developed without explicitly using traditional Lean Construction methods and metrics. The takt-like approach can be referred to as “synchronized multi-site scheduling”. By default, process plans start from a location-based structure, where basic units are usually floors of multi-story buildings. The schedule chart features a network representation: the vertical axis accommodates the locations (construction zones), and the horizontal axis indicates time. When planning becomes more detailed, the processes of each discipline are broken down into smaller zones within each floor. Another common characteristic in Company C projects is the standardization of work sequences. A logical sequence of major works is established and repeated across floors or construction zones. This is evident in residential projects, specifically in structural frames, finishings, and MEP. Each team has more flexible (i.e., slightly varying) time durations compared to traditional implementations of takt production.

In the rolling planning structure, takt is more evident in long-term planning (i.e., strategic takt). Company C uses a combination of backward planning from deadlines and milestones (akin to reverse planning in the LPS), practical experience of the project manager and planning team, reference to records of past projects with similar characteristics, and active consultation with suppliers and related trades on the feasibility of tentative plans. Since takt is more apparent at the master plan level, the standardized sequence of work tends to extend over large time spans (for instance, n working days for a precast concrete structural frame or interior finishing works of a high-rise residential building). Variations from each building typology (e.g., floor-to-floor design variations, differences in material quantities and assembly workload) are absorbed in mid- and short-term plans. Therefore, work packages can be somewhat flexible in work duration. In summary, it reflects a location-based plan with a standard work sequence, in which some processes are takted.

Takt production good practices include: (1) integration with a LPS equivalent and kaizen; (2) interdisciplinary collaboration; (3) mock-up construction to test the suitability of the takt sequence; (4) use of visual management devices on-site for process representation; and (5) continuous improvement initiatives. Table 5 presents the metrics systematically used by Company C.

Table 5: Metrics adopted by Company C

Metric	Definition
Adherence to schedule	Daily work is recorded in database by subcontractors and approved by project management teams, generating a daily report. Punctuality is monitored in a progress line, generated from a network-based schedule.
Labour productivity	Project performance was evaluated by using labour productivity, which is divided in Construction Management and Operational Work categories.

DISCUSSION AND CONCLUSION

The findings show that takt metrics are part of a broader performance measurement system and can be applied in different ways: as a comprehensive system (e.g., Case A), integrated through other planning systems (e.g., Case B), or through some tacitly implemented practices (e.g., Case C). Takt performance measurement were present in all three companies at different maturity levels. Company A had the highest level of maturity in terms of PMS: a wide range of good practices related to takt performance measurement were implemented, being complemented by the adoption of the standardized work approach and *gemba* walks to support process synchronization. Company B operated a planning and control PMS fully based on the LPS and was the only one that relied on digital platforms for planning and control, one aligned with LPS and another specifically for takt production. Company C applied the concept of takt time but adopted limited leading performance metrics.

Punctuality metrics were common across all three companies, as they are relatively easy to implement and because deviations from plans pose significant risks. Delays can lead to cascading impacts, including increased costs and the inability to meet demand (Hamzeh et al., 2012; Koskela, 2004), which compels companies to closely monitor schedule adherence and recover from deviations as quickly as possible. All three companies had formal quality management systems; however, quality-related metrics were not used to support the implementation of takt production. The only exception was in Company A, in which there was a metric for monitoring unfinished work zones, which may lead to the increase of WIP and re-entrant flows. None of the companies used metrics for assessing flow performance, involvement of the supply chain in takt production, adaptive capacity, or the consumption of slack.

Although LPS metrics are among the most frequently reported in the literature (Ballard and Tommelein, 2021; Jang and Kim, 2007), only Companies A and B applied them, both for assessing plan reliability. Alternatively, Company C emphasized daily control of planning effectiveness rather than formal LPS metrics. Work-in-progress (WIP) control was adopted only by Company A, based on the matrix of production status.

Despite some continuous improvement initiatives in all three companies, such as the use of strategic goal and action maps adopted by Company A, and ad hoc color-up meetings in Company B, adaptive capacity was not addressed by performance measurement. We argue that adaptive capacity plays a critical role in linking short-term performance metrics (e.g., punctuality) with long-term organizational change (e.g., process improvement and capability development). Moreover, it has the potential to capture intangible organizational aspects, such as employee motivation and learning (Woods, 2018). In other areas, such as oil and gas (Bento et al., 2021) and healthcare (Anderson et al., 2020) the concept of adaptive capacity has been implemented to support real-time decision-making and enhance the ability to respond to variability and disruptions. Therefore, adaptive capacity could be more effectively integrated with reliability planning and quality control measures. Likewise, no leading metrics were identified for assessing the extent or success of continuous improvement adoption across the companies.

Therefore, some research gaps improvement opportunities emerged from the three case studies, which is also useful to implement PMSs: (a) emphasize the use of leading metrics, strongly related to intermediate objectives; (b) extend the implementation of takt production metrics to other processes (e.g. material supply and quality management); (c) introduce metrics that could be used for supporting adaptive capacity and promoting takt recovery, such as the ones related to production status, early warnings, and projection of future performance. The development and implementation of PMS should consider the purpose of takt production and intermediate goals, informing the source of data to develop the metrics.

The findings also show that, differently from the Last Planner System, takt production systems have a low level of standardization of performance metrics. This is partly due to the fact that the level of maturity of takt production is diverse, and also due to specific characteristics of each construction project, such as degree of repetition, possibility of synchronizing processes, and types of complexity that exist. In fact, some of the metrics identified in this investigation are applicable only to processes that are takted, while other metrics are relevant to all processes, even the ones that are not takted.

Finally, it is important to emphasize that this study is not free of limitations. The analysis relied primarily on reported takt practices which implies that some metrics may have been overlooked. Future studies could further extend the list of metrics identified in this investigation, such as flow-related and slack metrics, and test in empirical studies new metrics related to concepts that have not much explored in the industry. In particular, adaptive capacity represents a promising area for exploring the relationship between short-term performance measures and long-term organizational outcomes. Another limitation is that this paper is an exploratory study, aiming to provide an initial investigation on conceptual aspects related to takt production metrics. As such, the empirical analysis is designed to discuss emerging concepts and identify patterns rather than to deliver fully developed analytical generalizations. Further studies on the development of PMS, containing sets of leading and lagging metrics, are necessary to support future implementations of takt performance measurement.

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