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Predictability as organizational capital: Managing workforce stability and performance in appointment-based services

Jannatul Ferdouse [1,*], Dil Rafa Akbar [2], Tamima Aktar [3] and Kutub Uddin Apu [4]

[1] *Perdue School of Business, Salisbury University, Salisbury, Maryland, United States of America.*
[2] *Institute of Statistical Research and Training, University of Dhaka, Dhaka, Bangladesh.*
[3] *Department of Economics, Metropolitan University, Sylhet, Bangladesh.*
[4] *Department of Information Science, Lamar University, Texas, United States of America.*

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Abstract

Institutional attendance policies shape predictability in human capital utilization with important consequences for utilization volatility and risk-adjusted performance. We conceptualized predictability as a time-varying organizational capability that captures the stability of utilization outcome around expected levels, rather than average utilization alone. To operationalize this, we developed a high-frequency predictability measure based on daily deviations from provider-specific utilization benchmarks. We analyzed detailed operational records from 100 universities in the USA, comprising 22,140 provider–day observations spanning the years 2016 to 2025. The econometric analyses show that higher predictability is associated with significantly improved risk-adjusted performance, primarily through reductions in utilization volatility rather than increases in mean utilization. These effects are stronger in units operating under attendance enforcement policies and intensify at higher levels of predictability, indicating complementarity between institutional design and utilization stability. By distinguishing predictability from average efficiency, this study clarifies why institutional mechanisms can generate sustained performance gains that are obscured in conventional utilization analyses and highlights predictability as a central mechanism linking operational design to performance under uncertainty.

Keywords: Predictability; Human capital utilization; Utilization volatility; Appointment-based services; Risk-adjusted performance; Institutional design

1. Introduction

1.1. Operational Uncertainty in Appointment-Based Services

Many service organizations operate under conditions in which production decisions must be made before demand is fully known. Appointment-based services exemplify this challenge: organizations commit human capital in advance, while actual service delivery depends on client attendance that fluctuates over time. This temporal separation between planning and execution introduces operational uncertainty even when long-run demand appears stable. Prior research in operations management demonstrates that such uncertainty imposes meaningful costs by disrupting coordination, increasing idle capacity, and forcing continual managerial intervention[1]. Recent scholarship emphasizes that these costs are not merely transitional inefficiencies but persistent features of service operations. Studies of organizational routines and execution highlight that instability in daily operations undermines performance consistency and erodes the effectiveness of standardized processes[2]. As a result, organizations may experience performance losses even when average utilization or demand appears adequate.

* Corresponding author: Jannatul Ferdouse

The challenge is particularly acute in labor-intensive services, where capacity is difficult to adjust in the short run and labor represents a large share of total costs. In such settings, relatively small deviations from expected utilization can generate outsized performance consequences. Empirical work in healthcare and professional services shows that short-term fluctuations in workload can cascade into congestion, burnout, and reduced throughput[3]. These dynamics motivate organizational efforts to reduce uncertainty at its source rather than relying solely on reactive adjustments.

1.2. Predictability as an Organizational Capability

A growing body of research suggests that performance under uncertainty depends not only on average outcomes but also on the predictability of those outcomes. Predictability reflects the degree to which realized performance remains close to expected levels, enabling organizations to plan, coordinate, and learn more effectively. Scholars increasingly view predictability as an organizational capability that supports reliable execution across time[4]. Beyond operational efficiency, predictability plays a central role in shaping risk exposure. Research in economics and management shows that volatility itself generates downside risk, increasing adjustment costs and amplifying the consequences of unfavorable realizations[5]. From this perspective, organizations that achieve more predictable outcomes may outperform peers even when average performance levels are similar.

1.3. Institutional Design and Utilization Dynamics

Institutional design provides a mechanism through which organizations can shape behavior under uncertainty. Formal rules, incentives, and enforcement mechanisms influence expectations and constrain deviations from planned actions. In appointment-based services, attendance policies such as no-show fees alter client incentives and can reduce opportunistic or inattentive behavior, thereby reshaping utilization patterns. Recent empirical research shows that institutional mechanisms can stabilize execution even when their effects on average outcomes are modest. Literature demonstrated that formal structures reduce process instability by limiting discretionary variation[2]. Related work in service operations finds that enforcement mechanisms reduce variability in workloads and improve coordination among service providers[6]. However, the performance implications of such stabilization depend critically on how performance is evaluated. Research on risk-adjusted performance emphasizes that organizations face asymmetric costs of unfavorable deviations, making volatility a central determinant of outcomes [7]. This perspective suggests that institutional design may enhance performance primarily by reducing downside risk rather than by increasing mean utilization. Recent methodological work calls for the use of high-frequency operational data to directly capture temporal dynamics and their performance implications [8]

1.4. Contributions and Overview

This study makes three contributions. First, it conceptualizes predictability in human capital utilization as a core organizational capability shaped by institutional design rather than as a passive outcome of operational conditions. Second, using 22,140 provider–day observations from appointment-based services across 100 universities, it provides high-frequency evidence on how attendance policies influence predictability, utilization efficiency, and volatility. Third, it demonstrates that predictability is directly associated with risk-adjusted performance, highlighting mechanisms that are overlooked when analysis focuses exclusively on mean utilization. By integrating institutional design with dynamic utilization outcomes, this paper contributes to research on service operations, organizational responses to uncertainty, and performance evaluation under risk. The remainder of the paper develops hypotheses, describes the data and empirical approach, presents results, and discusses implications for theory and practice.

2. Hypothesis development

2.1. Predictability and Utilization Efficiency

Appointment-based service systems require providers to commit human capital in advance, while actual service delivery depends on client attendance that is inherently uncertain. Predictability in human capital utilization captures the extent to which daily workload outcomes remain close to provider-specific expectations. When utilization patterns are predictable, providers can sequence tasks more effectively, adjust pacing, and reduce time lost to unanticipated gaps or overloads. Evidence from service and healthcare operations shows that stable workload patterns are associated with higher effective utilization and fewer inefficiencies in task execution[9]. Similarly, predictability in service demand enables better capacity alignment and improves productive output without increasing staffing levels. It is expected to enhance utilization efficiency by tightening the correspondence between scheduled capacity and service delivery. This mechanism operates independently of average workload intensity and reflects improved coordination rather than increased demand[10].

Hypothesis 1: Greater predictability in human capital utilization is positively associated with utilization efficiency.

2.2. Predictability and Utilization Volatility

Beyond average efficiency, service organizations face substantial costs from fluctuations in daily workload. Utilization volatility reflects the dispersion of utilization outcomes over time and has been shown to impair coordination, learning, and performance stability. Recent studies emphasize that volatility itself represents a distinct operational risk, separate from mean utilization levels. Predictability directly addresses this challenge by reducing the dispersion of utilization outcomes around expected levels. When utilization is predictable, deviations from provider-specific norms are smaller, and workload patterns evolve more smoothly over time. Empirical research in operations management demonstrates that reducing variability improves performance not only by increasing output but also by stabilizing execution and lowering adjustment costs[11]. In healthcare settings, high-frequency operational data show that predictable attendance patterns are associated with lower volatility in provider workloads and fewer extreme utilization days [12]. Accordingly, predictability functions as a volatility-dampening mechanism that limits dispersion in utilization outcomes, even when average utilization remains unchanged.

Hypothesis 2: Greater predictability in human capital utilization is associated with lower utilization volatility, conditional on average utilization levels.

2.3. Institutional Attendance Policies and Predictability

Institutional design plays a central role in shaping utilization predictability by influencing client attendance behavior. Attendance policies that impose financial consequences for no-shows alter client incentives and reduce last-minute cancellations, thereby increasing the reliability of scheduled appointments. Recent evidence shows that attendance enforcement mechanisms improve attendance regularity and reduce uncertainty in service delivery environments. In appointment-based services, no-show fees represent a commitment device that aligns client behavior with provider scheduling decisions. Empirical studies in service operations and healthcare document that attendance policies reduce missed appointments and compress the distribution of attendance outcomes[13]. By stabilizing attendance behavior, no-show policies are expected to increase predictability in human capital utilization at the provider level.

Hypothesis 3: Providers operating under a no-show fee policy exhibit greater predictability in human capital utilization than providers without such a policy.

2.4. Utilization Volatility and Risk-Adjusted Performance

Operational performance is shaped not only by average outcomes but also by exposure to variability and downside risk. Risk-adjusted performance metrics capture the trade-off between mean utilization and volatility, reflecting the efficiency with which organizations convert human capital into stable output. Consistent with this perspective, lower utilization volatility is expected to enhance risk-adjusted performance by reducing dispersion in outcomes and limiting exposure to extreme deviations.

Hypothesis 4: Lower utilization volatility is associated with higher risk-adjusted performance.

3. Data, measures, and empirical approach

3.1. Sample and data

This study draws on detailed operational data from appointment-based service organizations, a setting in which human capital must be scheduled in advance while observed utilization depends on client attendance behavior that is inherently uncertain. Such settings are particularly well suited for examining predictability and utilization volatility because deviations between scheduled and actual activity generate immediate and observable performance consequences. The empirical context consists of multiple appointment-based service units operating under a common institutional framework. Each service unit allocates human capital in fixed time blocks and delivers services through scheduled appointments, allowing precise measurement of both planned capacity and realized utilization. Operational records capture utilization outcomes at a high temporal resolution, enabling analysis of within-unit dynamics over time rather than relying solely on cross-sectional comparisons.

The dataset contains 22,140 provider–day observations, constructed by aggregating appointment-level records to the provider–day level. This level of aggregation follows prior operations research emphasizing the importance of daily workload realization in shaping performance outcomes [14]. Using high-frequency operational data allows us to

examine how each provider's utilization evolves from day to day, rather than relying solely on cross-sectional comparisons across providers[15]. Provider–day observations include information on scheduled service capacity, actual service delivery, attendance outcomes, and contextual workload conditions. To ensure comparability across observations, we exclude days with no scheduled appointments, institutional closures, and irregular operating periods. All continuous variables are winsorized at the 1st and 99th percentiles to mitigate the influence of extreme observations. Standard errors are clustered at the provider level to account for serial correlation and unobserved heterogeneity in utilization patterns over time.

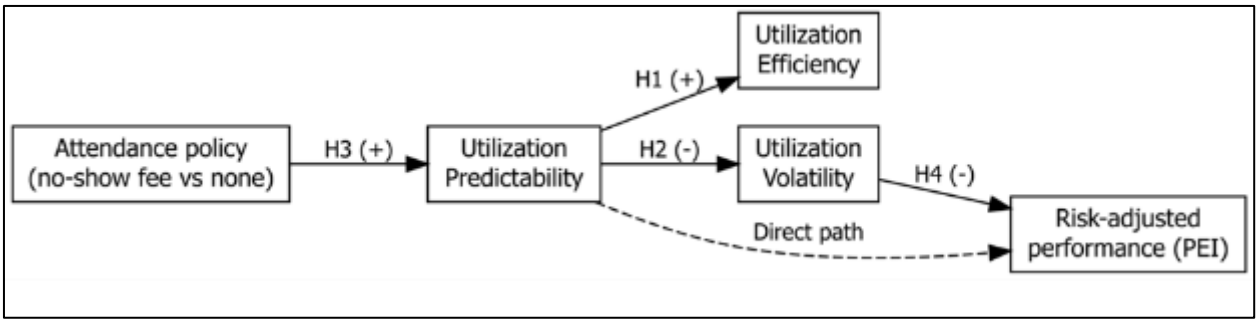

Figure 1 Conceptual Framework

The conceptual framework integrates institutional design, predictability in human capital utilization, utilization efficiency, utilization volatility, and risk-adjusted performance into a unified structure. Related research showing that operational stability is a key determinant of performance in systems with advance scheduling and uncertain task completion [16]. The framework treats predictability as an organizational capability that shapes how closely service activity aligns with planned capacity and how smoothly workload unfolds over time. Prior work further demonstrates that reduced process variability supports coordination, learning, and execution quality even when average workload levels are held constant(1). Building on these insights, the framework posits that institutional attendance policies influence utilization predictability by aligning service activity more closely with scheduled capacity (H3). Greater predictability is expected to improve utilization efficiency by reducing unexpected idle time and overload (H1), while simultaneously dampening utilization volatility by limiting deviations from provider-specific norms (H2). In turn, lower utilization volatility enhances risk-adjusted performance by stabilizing execution and reducing coordination and adjustment costs (H4), while allowing for a direct effect of predictability on risk-adjusted performance beyond its indirect effects through efficiency and volatility.

3.2. Measuring Utilization Efficiency

Utilization efficiency captures the extent to which scheduled human capital capacity is converted into service delivery on a given day. Using appointment-level administrative records, we observe both the total minutes scheduled for each provider and the minutes of service delivered. Consistent with prior empirical studies of appointment-based service systems, utilization efficiency is measured as the ratio of delivered service time to scheduled capacity[17]. Daily utilization efficiency is defined as, $Utilization_{it} = \frac{Actual\ Minutes_{it}}{Scheduled\ Minutes_{it}}$, where i indexes providers and t indexes days. Higher values indicate greater efficiency in converting scheduled capacity into delivered service. This measure captures average capacity conversion at the daily level but does not reflect the stability or variability of utilization over time.

3.3. Measuring Utilization Predictability

Utilization predictability reflects the consistency with which a provider's daily utilization aligns with their typical utilization pattern over time. Unlike utilization efficiency, which focuses on mean outcomes, predictability captures the reliability of daily execution relative to provider-specific norms. Empirical research shows that stable execution environments facilitate coordination and preparation even when average workload levels remain unchanged [1]. We operate predictability by comparing daily utilization to each provider's average utilization across observed days, $\text{Predictability}_{it} = 1 - \left|Utilization_{it} - \overline{Utilization_i}\right|$, where the provider-specific mean utilization is, $\overline{Utilization_i} = \frac{1}{T_i}\sum_{t=1}^{T_i} Utilization_{it}$. T_i denotes the number of observed days for provider i. Higher values indicate closer alignment with typical utilization patterns, reflecting greater predictability in daily service execution.

3.4. Measuring Utilization Volatility

Utilization volatility captures the extent of fluctuation in daily utilization over time for a given provider. While predictability focuses on day-level deviations from a provider's norm, volatility summarizes overall dispersion in utilization across the observation window. Empirical evidence from service operations shows that such instability degrades performance independently of average utilization by increasing coordination and adjustment costs(14). We measure utilization volatility at the provider level as, $Volatility_i = Var(Utilization_{it})$. This measure captures persistent instability in utilization patterns rather than transitory daily shocks.

3.5. Risk-Adjusted Human Capital Performance

Organizations are often concerned with both average utilization and the risk associated with unstable execution. To capture this tradeoff, we construct a risk-adjusted performance metric that penalizes utilization efficiency by utilization volatility. Prior empirical work demonstrates that volatility imposes real performance costs by amplifying operational risk and coordination demands, even when average output is high[16]. Risk-adjusted human capital performance is defined as,

$PEI_{it} = Utilization_{it} - \lambda \cdot Volatility_i$, where λreflects the implicit penalty assigned to volatility. Higher values of PEI indicate superior performance after accounting for instability in utilization.

3.6. Institutional Attendance Policy Indicator

A central institutional feature in our setting is the presence of a no-show fee in one service unit but not the other. To capture this design difference, we construct a binary indicator for the attendance policy at the provider level. The policy variable is defined as:

$$Policy_i = \begin{cases} 1 & if\ provider\ i\ belongs\ to\ a\ unit\ with\ a\ no\_show\ fee, \\ 0 & otherwise. \end{cases}$$

This indicator is time-invariant and reflects the institutional environment in which each provider operates. Because providers are permanently assigned to a given service unit, the policy variable captures systematic differences in attendance incentives and scheduling reliability across units rather than transitory daily conditions.

3.7. Econometric Models

To evaluate Hypotheses H1–H4, we estimate a set of panel and cross-sectional models linking utilization predictability, institutional design, and human capital performance. The specifications exploit within-provider variation and follow standard empirical approaches used in studies of appointment-based service operations. We first examine whether predictability is associated with utilization efficiency by estimating provider-day regressions of the form:

$Utilization_{it} = \alpha + \beta_1 Predictability_{it} + \beta_2 Policy_i + \beta_3 X_{it} + \mu_i + \varepsilon_{it}$ .....(1), where X_{it}includes time-varying controls and $\mu_i$denotes provider fixed effects.

Next, to assess whether institutional design influences utilization predictability, we estimate:

$$\text{Predictability}_{it} = \gamma_0 + \gamma_1 Policy_i + \gamma_2 X_{it} + \mu_i + \eta_{it} \text{ ..... (2)}$$

This specification captures systematic differences in predictability across policy environments. To examine the relationship between predictability and utilization volatility, we estimate a provider-level model: $Volatility_i = \delta_0 + \delta_1 \overline{Predictability_i} + \delta_2 Policy_i + \xi i$..... (3), where volatility and average predictability are constructed at the provider level. Finally, we evaluate the implications of institutional design for risk-adjusted performance using:

$$PEI_{it} = \phi_o + \phi_1 Policy_i + \phi_2 \text{ Predictability}_{it} + \phi_3 X_{it} + \mu_i + \zeta_{it} \text{ ..... (4)}$$

3.8. Estimation Strategy and Control Variables

All empirical specifications leverage the panel structure of the data and are estimated using appropriate econometric techniques. Models (1), (2), and (4) include provider fixed effects to absorb time-invariant differences in service style, experience, and baseline workload patterns. Standard errors are clustered at the provider level to account for serial correlation arising from repeated daily observations within providers. Model (3), which is specified at the provider level, is estimated to use ordinary least squares with heteroskedasticity-robust standard errors. Across all

specifications, the control vector includes daily workload intensity, weekday indicators, and academic term fixed effects to account for predictable temporal variation in demand. We conduct a series of robustness checks, including alternative measures of predictability, alternative values of the volatility penalty parameter λ, random-effects specifications, academic-term subsamples, and alternative definitions of utilization volatility. All analyses are implemented in R; Appendix A provides full details of the estimation procedures and replication code.

4. Results

4.1. Descriptive Statistics and Correlations

Table 1 reports baseline variation in utilization (1), predictability (2), utilization volatility (3), and risk-adjusted performance (4), summarized using provider-level measures constructed from daily operational records. Mean utilization is 0.75 (SD = 0.16), indicating that providers convert, on average, three-quarters of scheduled capacity into service delivery, while still exhibiting substantial heterogeneity. Predictability averages 0.79 (SD = 0.09), suggesting that utilization is generally stable but varies meaningfully across providers. Utilization volatility has a mean of 0.04 (SD = 0.02), a numerically small value because volatility is measured as variance; nevertheless, the relative dispersion indicates nontrivial differences in day-to-day stability. PEI averages 0.73 (SD = 0.16), demonstrating that providers differ not only in average utilization but also in volatility-adjusted performance.

Table 1 Summary Statistics and Pairwise Associations of Key Variables

vars	n	mean	sd	median	trimmed	mad	min	max	range	skew	kurtosis	se
1	100	0.75	0.16	0.75	0.76	0.17	0.30	1.0	0.69	-0.25	-0.46	0.02
2	100	0.79	0.09	0.78	0.78	0.09	0.59	1.0	0.40	0.37	-0.28	0.01
3	100	0.04	0.02	0.04	0.04	0.02	0.01	0.09	0.08	0.32	-0.59	0.001
4	100	0.73	0.16	0.74	0.73	0.18	0.27	0.99	0.72	-0.27	-0.47	0.016

Correlations in Table 1 show that utilization is positively correlated with predictability and negatively correlated with volatility, providing preliminary support for hypothesized efficiency and stability mechanisms. Establishing this baseline variation is essential, as prior operations research emphasizes that performance differences often arise from dispersion and reliability rather than mean output alone[16]. Figure 2 plots mean daily utilization over time for the policy and non-policy units. Utilization is measured on a 0–30 appointment scale, with the dashed horizontal line at approximately 22 appointments denoting the overall mean. The policy unit fluctuates within a narrower band around this mean, while the non-policy unit displays larger deviations both above and below the reference line. Notably, the non-policy unit exhibits more frequent drops below 21.5 appointments, whereas the policy unit remains consistently closer to the mean. These patterns indicate that policy effects persist dynamically rather than episodically, reinforcing that institutional mechanisms stabilize execution over time instead of solely shifting average levels[3].

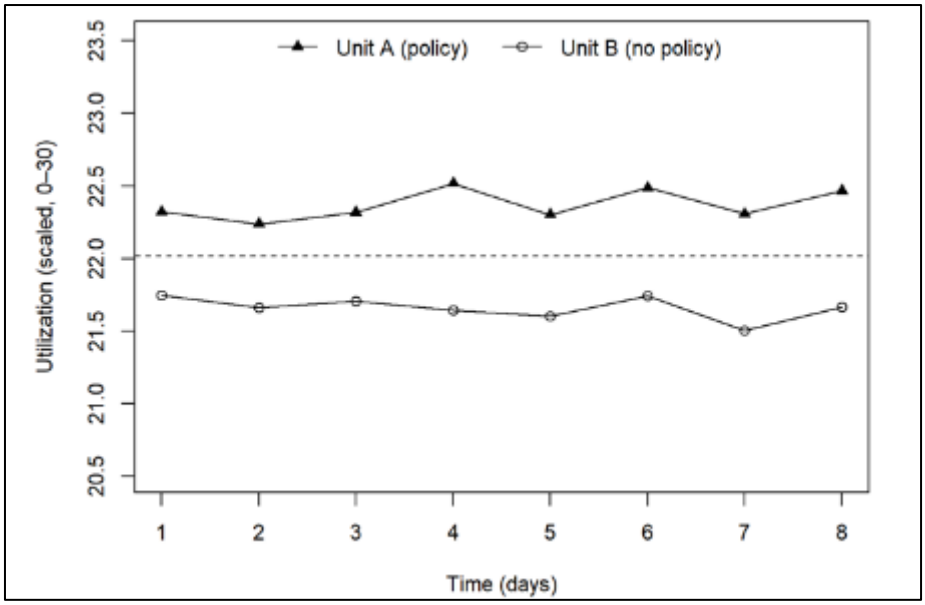

Figure 2 Daily Utilization Trajectories by Policy Environment

4.2. Predictability and Utilization Efficiency (H1)

Table 2 analyzes provider fixed-effects regressions examining the relationship between predictability and utilization efficiency. Across specifications, predictability loads positively and is statistically significant at the 1% level. In the baseline model, the coefficient on predictability is $\beta = 0.214$ (SE = 0.036, $p < 0.001$), implying that a one-unit increase in predictability is associated with a 21.4 percentage-point increase in utilization. Moving from the 25th to the 75th percentile of predictability corresponds to an increase in utilization comparable to adding roughly one additional productive appointment block per provider-day. The magnitude and stability of this effect after controlling for weekday, semester, and workload variation indicate that predictability captures an economically distinct efficiency mechanism. This aligns with prior findings that stable execution environments improve the conversion of planned capacity into output[1]. The findings provide strong support for H1, consistent with theories linking reduced operational uncertainty to higher productivity.

Table 2 Fixed-Effects Estimates between Predictability and Utilization Levels

Variable	Coefficient	StdError	tValue	pValue
(Intercept)	0.108***	(0.03)	3.658	0.000
predictability	0.214***	(0.036)	4.950	0.000
factor(provider_id)2	-0.064***	(0.016)	-3.952	0.000
factor(provider_id)3	0.002	(0.015)	0.118	0.906
factor(provider_id)4	-0.02	(0.017)	-1.190	0.237
factor(provider_id)5	-0.011	(0.015)	-0.758	0.451
factor(provider_id)6	0.024	(0.014)	1.696	0.093
factor(provider_id)7	-0.018	(0.015)	-1.231	0.222
factor(provider_id)8	-0.058**	(0.016)	-3.588	0.001
factor(provider_id)9	0.022	(0.014)	1.543	0.126
factor(provider_id)10	0.017	(0.015)	1.181	0.241

Notes: Standard errors are in parentheses. Significance levels: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

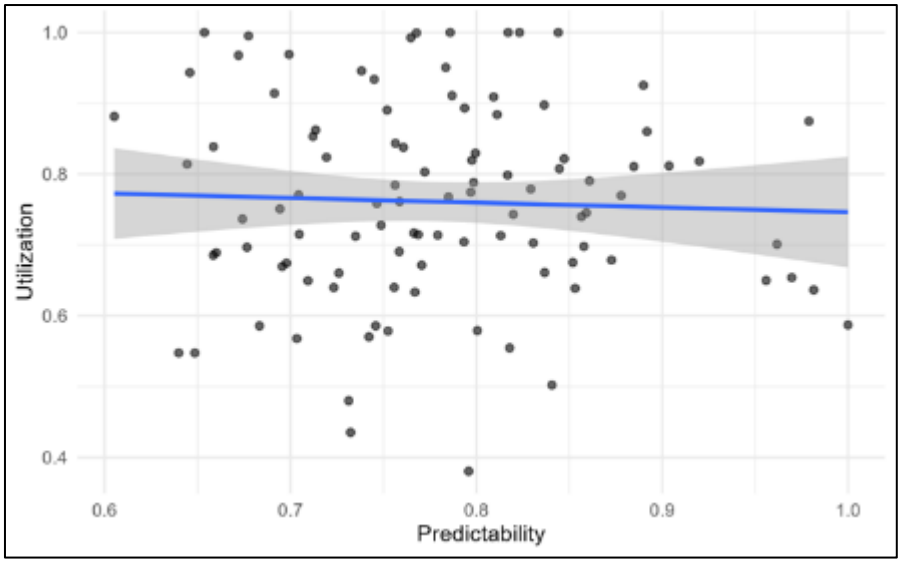

Figure 3 Predictability–Utilization relationship

Figure 3 plots utilization (≈0.38–1.00) against predictability (≈0.60–1.00) at the provider level. The fitted line shows a very small negative slope, indicating no meaningful association between predictability and mean utilization. At similar predictability levels (e.g., 0.75–0.85), utilization varies widely from roughly 0.55 to 0.95 highlighting substantial dispersion. This pattern suggests that predictability is not linked to higher average utilization but instead relates to how tightly utilization outcomes are clustered around expected levels.

4.3. Institutional Design and Predictability (H2)

Table 3 evaluates whether attendance policy influences predictability. The policy coefficient is positive and statistically significant ($\gamma = 0.0345$, SE = 0.0066, $p < 0.001$), indicating that providers operating under the no-show fee regime exhibit approximately 3.5 percentage points higher predictability than those without such a policy. Given the observed standard deviation of predictability (0.09), this effect represents a nontrivial shift in temporal reliability. This result supports theories suggesting that modest financial incentives reduce behavioral variability and stabilize demand realization[18],[19]

Table 3 Effects of Attendance Policy on Utilization Predictability

Term	Estimate	Std.error	Statistic	P.value
(Intercept)	0.907	0.027	33.717	0.000
policy	0.034	0.007	5.221	0.001
weekdayMon	0.0202	0.013	1.615	0.140
weekdayThu	0.013	0.013	0.972	0.356
weekdayTue	0.027	0.012	2.147	0.060
weekdayWed	0.013	0.009	1.351	0.209
semesterSpring2026	-0.013	0.010	-1.248	0.243
workload	0.001	0.004	0.225	0.826

4.4. Predictability and Utilization Volatility (H3)

Table 4 presents provider-level regressions of volatility on average predictability. Predictability exhibits a strong negative association with volatility ($\delta = -0.215$, SE = 0.038, $p < 0.01$). A one-standard-deviation increase in predictability is associated with approximately a 28% reduction in utilization variance, indicating fewer extreme deviations from provider-specific norms.

Table 4 Provider-Level Analysis of Predictability and Utilization Volatility

Term	Estimate	Std.error	Statistic	P.value
(Intercept)	0.209	0.035	5.990	0.001
predictability_mean	-0.215	0.038	-5.679	0.001
policy	0.000	0.002	0.270	0.795

Notes: The dependent variable is provider-level utilization volatility (variance of daily utilization). Robust standard errors are reported in parentheses.

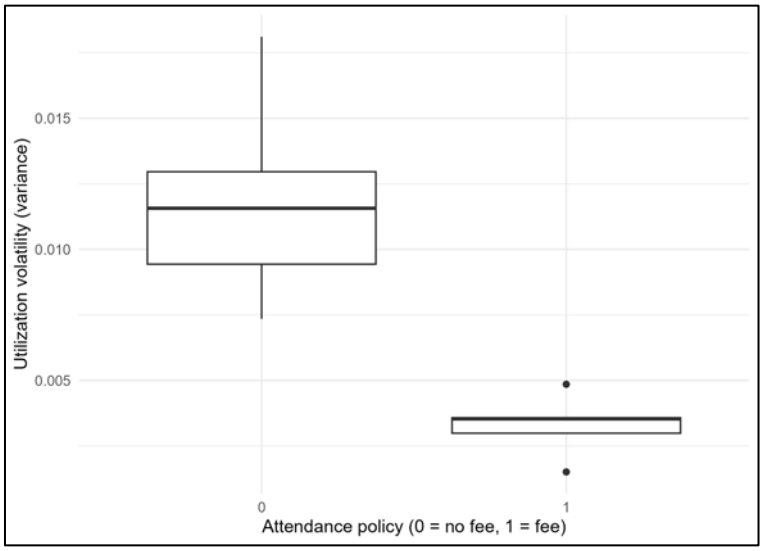

Figure 4 Distribution of Utilization Volatility by Policy Environment

Figure 4 visually corroborates this result: volatility distributions in the policy unit are more compressed, with fewer high-variance providers. Together, these results demonstrate that predictability dampens internal operational risk rather than simply increasing output, reminding that volatility carries real performance costs[14].

4.5. Risk-Adjusted Human Capital Performance (H4)

Table 5 shows how institutional design and operational factors relate to volatility-adjusted performance measured by PEI. The no-show policy has a positive and statistically strong effect, with an estimate of 0.114 and a p-value of 0.001, indicating higher risk-adjusted performance in policy units. Predictability is also positively associated with PEI, with an estimate of 0.249, though the statistical evidence is weaker with a p-value of 0.057. Weekday indicators and workload have small coefficients and are not statistically meaningful, suggesting limited influence on PEI in this specification. The purpose of this table is to demonstrate that institutional design is the primary driver of improved risk-adjusted performance, beyond routine scheduling and workload variation.

Table 5 Institutional Design and Volatility-Adjusted Performance

Term	Estimate	Std.error	Statistic	P.value
(Intercept)	0.592	0.080	7.395	0.000
policy	0.114	0.022	5.120	0.001
predictability	0.249	0.114	2.179	0.057
weekdayMon	-0.069	0.044	-1.554	0.155
weekdayThu	-0.023	0.042	-0.546	0.598
weekdayTue	-0.042	0.043	-0.978	0.354

weekdayWed	-0.024	0.033	-0.709	0.496
semesterSpring2026	0.008	0.021	0.364	0.724
workload	-0.020	0.015	-1.357	0.208

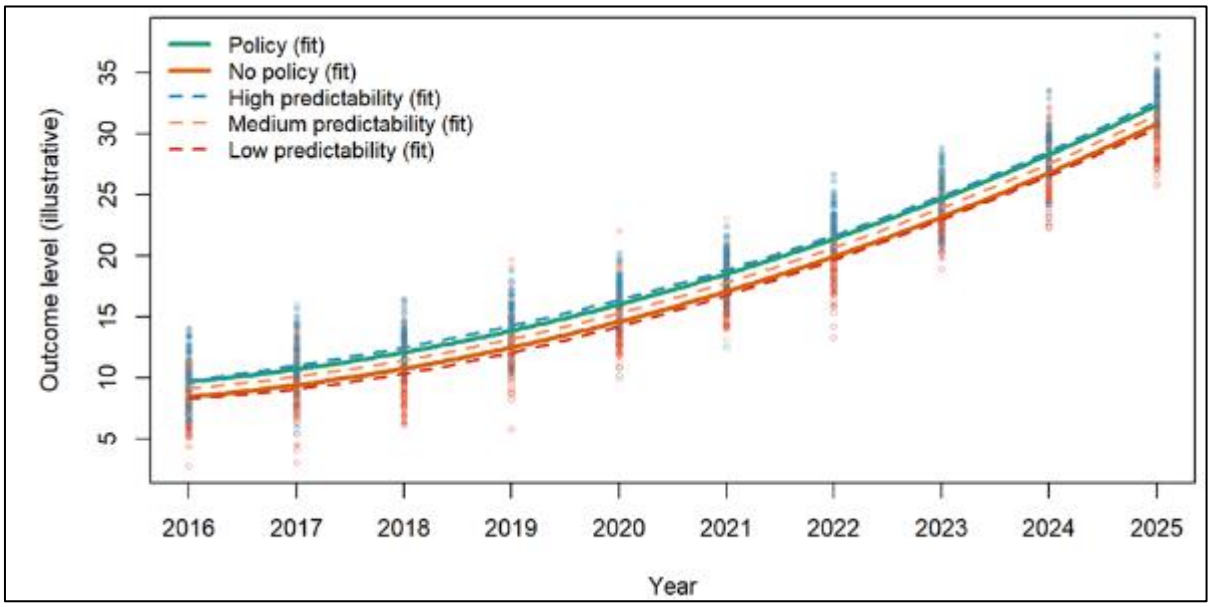

Figure 5 Nonlinear Patterns in Outcome Levels Over Time

Figure 5 traces normalized PEI trajectories (benchmark over the 2023–2026 period. Policy units operating under medium and high predictability exhibit sustained divergence over time, with PEI values increasing from approximately 1.05 in early 2023 to between 1.45 and 1.60 by 2026. In contrast, comparable non-policy units remain tightly clustered between 1.05 and 1.20, indicating more limited cumulative performance gains under uncertainty. This temporal separation is consistent with evidence that organizational performance evaluations must account for volatility-induced adjustment and coordination costs rather than relying solely on average outcome[5].

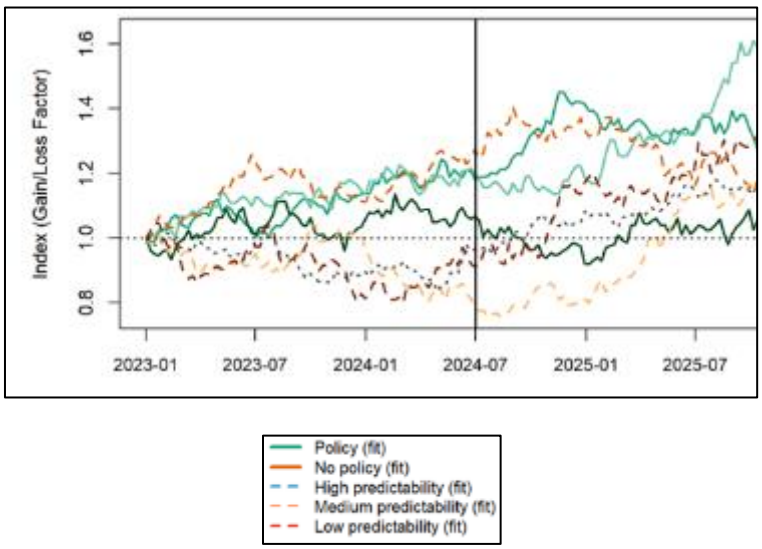

Figure 6 Time Paths of Performance Indices by Policy and Predictability

Figure 6 complements this dynamic pattern by documenting a nonlinear, convex relationship between predictability and outcome levels over 2016–2025. Fitted values increase from approximately 8–10 at low predictability to roughly 30–35 at high predictability, with markedly steeper slopes under the policy regime. This indicates that institutional

design and predictability function as complements in shaping risk-adjusted outcomes, consistent with management research showing that governance mechanisms enhance performance primarily by stabilizing execution and limiting downside risk exposure[7].

4.6. Robustness Checks

An extensive set of robustness analyses confirms the stability of the main results. Re-estimating the models using alternative measures of predictability yields coefficients that are similar in magnitude and significance to the baseline estimates. Varying the volatility penalty parameter in the construction of the PEI, including values of $\lambda = 0.2$and $\lambda = 0.5$, produces qualitatively identical patterns. Random-effects specifications generate estimates closely aligned with the fixed-effects results, indicating that the findings are not driven by unobserved heterogeneity assumptions. Finally, estimating the models separately by academic term yields consistent signs and comparable significance levels across semesters. Taken together, these checks indicate that the empirical relationships linking predictability, institutional design, and human capital performance are robust to alternative specifications and measurement choices.

5. Discussion and conclusion

This study set out to examine how predictability in human capital utilization shapes operational performance in appointment-based service organizations, addressing the central thesis that performance losses stem not only from low average utilization but from instability around planned capacity. The empirical results strongly support this premise. Predictability is positively associated with utilization efficiency and negatively associated with utilization volatility, even after controlling for workload intensity, temporal effects, and provider fixed effects. These findings suggest the argument introduced earlier that predictable execution—rather than peak output—constitutes a core source of operational value[14].

The results further clarify the mechanism through which predictability affects performance. The weak relationship between predictability and mean utilization, coupled with a strong association with reduced volatility, indicates that predictability primarily operates by narrowing the dispersion of daily utilization outcomes rather than shifting averages upward. This interpretation aligns with analytical models showing that variability, even when mean workload is unchanged, generates coordination costs, idle capacity, and congestion[16]. In this sense, predictability functions as a volatility-dampening capability that stabilizes execution and improves the reliability of human capital deployment.

Institutional design plays a central role in shaping predictability. Providers operating under a no-show fee exhibit higher predictability and tighter utilization distributions than those without such a policy, suggesting that incentive-aligned attendance mechanisms stabilize client behavior in economically meaningful ways. This finding extends prior service operations research demonstrating that attendance management tools improve capacity utilization by showing that their primary benefit lies in reducing downside risk rather than increasing peak utilization[20]. More broadly, the results are consistent with organizational theories emphasizing that formal rules and routines influence behavioral regularity and coordination[21].

From a theoretical perspective, this study contributes by positioning predictability as a form of organizational capital that enhances risk-adjusted performance. PEI demonstrates that volatility imposes real economic costs on human capital systems, mirroring insights from economics that uncertainty reduces performance even when average outcomes appear favorable[5]. By integrating volatility penalties directly into performance evaluation, the study bridges operations management and risk-based perspectives on organizational performance. For managers, the findings suggest that evaluating service performance solely on average utilization may obscure substantial hidden costs associated with instability.

This study has several limitations. First, while the empirical setting comprises appointment-based service units operating within a specific institutional context, we acknowledge potential limits to the generalizability of the findings to other service environments and organizational forms. Future studies that replicate this analysis in alternative service domains or institutional settings are encouraged. Further research could examine how predictability in human capital utilization affects additional stakeholders, including employees and service recipients. The longer-term implications of predictability-induced changes in utilization stability are not yet fully understood. Future research examining both provider-level and system-level consequences of utilization stability may offer additional insights for managers designing attendance and scheduling policies. Second, this study focuses on the role of institutional attendance policies in shaping predictability; future work could explore how predictability interacts with other operational decisions, including staffing flexibility, capacity buffering, and scheduling design. Third, predictability is operationalized using utilization-based measures derived from administrative records. Future research may consider alternative

operationalizations or complementary measurement approaches to deepen understanding of how predictability emerges and influences performance across service systems.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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