BULLETIN OF ENGINEERING SCIENCE, TECHNOLOGY AND INDUSTRY
(BESTI Journal) | ISSN(e): 3025-5821
Website: https://bestijournal.org/index.php/go/index | Volume 5 No. 1 (2027)

EFFECTS OF DIGITAL TRANSFORMATION, SERVICE INNOVATION, AND TECHNOLOGY LITERACY ON EMPLOYEE PERFORMANCE THROUGH WORK EFFECTIVENESS AT BATAM CUSTOMS

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Received: 11/08/2026 | **Revised:** 23/08/2026 | **Accepted:** 19/09/2026 | **Published:** 20/11/2026

Abstract

Digitalization in customs services requires organizational change, service innovation, and employees' capacity to use technology. This study examines the effects of digital transformation, service innovation, and technology literacy on employee performance through work effectiveness at the Batam Type B Main Customs and Excise Office. A sequential explanatory mixed methods design combined a census survey of 137 employees with interviews involving five key informants and a focus group discussion. Questionnaire data were analyzed using partial least squares structural equation modeling in SmartPLS 4.0. Digital transformation and service innovation were significantly and positively associated with work effectiveness, whereas technology literacy was not significantly associated with it. Technology literacy and work effectiveness were significantly and positively associated with employee performance; the direct effects of digital transformation and service innovation were not significant. Work effectiveness significantly mediated only the relationship between service innovation and employee performance. The reported model explained 78.0% of the variance in work effectiveness and 66.4% in employee performance. These findings suggest that performance improvement requires coordinated digital development, service redesign, and employee technology skills, with attention to the effectiveness of everyday work processes.

Keywords: digital transformation; employee performance; service innovation; technology literacy; work effectiveness

INTRODUCTION

Rapid advances in digital technology have reshaped public sector governance, including customs and excise services. Digital transformation has become a strategic priority for improving efficiency, transparency, and accountability in government organizations (Bharadwaj et al., 2013; Vial, 2019). The Batam Type B Main Customs and Excise Office, referred to here as KPU Bea Cukai Tipe B Batam, operates within the Directorate General of Customs and Excise and plays a strategic role in supporting the movement of goods, services, and investment in the Batam Free Trade Zone and Free Port.

Digital transformation extends beyond the introduction of applications and information systems. It also involves changes in work processes, organizational culture, governance, and employee competencies. Digital systems, electronic services, and integrated data are expected to accelerate service delivery and decision making. Their benefits, however, depend on service innovation and employees' ability to use technology effectively.

Preliminary internal evaluation at KPU Bea Cukai Tipe B Batam indicated digital system utilization of 62%, service innovation of 68%, employee technology literacy of 59%, work effectiveness of 65%, and employee performance of 70%. Between 32% and 38% of employees reportedly encountered duplicate data entry or technical problems; 30% considered service innovation to be predominantly initiated by management; and 27% to 35% had difficulty adapting to system updates. These preliminary indicators suggest gaps between technology implementation and effective work practices.

The practical challenges include duplicate data entry, system delays, continued reliance on manual procedures, uneven implementation of service innovations, and differences in employees' ability to operate applications and understand system updates. Such conditions may delay task completion and reduce the consistency

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of employee performance. Work effectiveness is therefore examined as a mechanism linking digital transformation, service innovation, and technology literacy to performance.

This study investigates the relationships of digital transformation, service innovation, and technology literacy with work effectiveness and employee performance. It also tests whether work effectiveness mediates the relationships between the three explanatory variables and performance. The analysis addresses a specific organizational problem: whether digital development and service improvements translate into better performance through more effective daily work processes.

LITERATURE REVIEW

Digital Transformation

Digital transformation is a process of organizational change enabled by digital technologies. It involves applications and information systems as well as work processes, organizational structures, governance, culture, and value creation. Organizations use digital transformation to become more adaptive, integrated, responsive, and data oriented (Vial, 2019). The study draws on dynamic capabilities theory (Teece, 2018) and the technology–organization–environment framework (Tornatzky & Fleischer, 1990). Its digital transformation indicators cover work process digitalization, information system integration, digital application use, processing speed and accuracy, and management support.

Service Innovation

Service innovation involves the creation of new services, improvements in service quality, changes in delivery processes, and the application of new technologies or working methods. Its value depends on practical implementation and improvements experienced by service users, rather than the generation of ideas alone (den Hertog et al., 2010). Innovation diffusion and service-dominant logic provide perspectives on how new practices are adopted and how value is created through service interactions (Rogers, 2003; Vargo & Lusch, 2004).

In public services, innovation may improve user satisfaction, reduce administrative costs, shorten service times, and support transparency and accountability through better service design and standardized procedures. Different forms of service innovation can create value through different mechanisms, which makes the implementation context relevant to performance outcomes (Helkkula et al., 2018).

Technology Literacy

Technology literacy refers to an individual's ability to access, understand, evaluate, use, and produce information through digital technologies effectively and responsibly. It includes technical skills, cognitive skills for assessing information quality, and social and emotional capabilities for safe and ethical participation in digital environments (Ng, 2012). In organizational settings, employees need these capabilities to operate digital systems, manage information, and adapt to changes in technology-based work procedures (van Deursen & van Dijk, 2016).

Work Effectiveness

Work effectiveness concerns the successful completion of tasks and achievement of work objectives in accordance with established standards. It includes timeliness, procedural accuracy, output quality, and the efficient use of available resources (Drucker, 1974; Robbins & Judge, 2017). Goal achievement also depends on clear targets and the processes through which employees direct and sustain their effort (Locke & Latham, 2002). In this study, work effectiveness is the proposed mediating variable: digital technology and service innovation may contribute to employee performance by enabling tasks to be completed more accurately, promptly, and consistently.

Employee Performance

Employee performance reflects achievement in relation to targets, output quality, timeliness, procedural compliance, and work behaviors that support organizational objectives. It is a multidimensional behavioral construct, rather than solely a measure of final output (Campbell, 1990). In public service organizations, employee performance is closely connected to service quality and organizational effectiveness. Performance under digital change also requires adaptation, collaboration, and appropriate use of digital systems (Pulakos et al., 2000).

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Research Hypotheses

The conceptual model treats digital transformation (DT), service innovation (SI), and technology literacy (TL) as explanatory variables, work effectiveness (WE) as the mediator, and employee performance (EP) as the outcome. The following hypotheses specify the direct and indirect relationships examined in the study.

H1: Digital transformation affects work effectiveness.
H2: Service innovation affects work effectiveness.
H3: Technology literacy affects work effectiveness.
H4: Digital transformation affects employee performance.
H5: Service innovation affects employee performance.
H6: Technology literacy affects employee performance.
H7: Work effectiveness affects employee performance.
H8: Work effectiveness mediates the effect of digital transformation on employee performance.
H9: Work effectiveness mediates the effect of service innovation on employee performance.
H10: Work effectiveness mediates the effect of technology literacy on employee performance.

METHOD

The study employed a sequential explanatory mixed methods design. Quantitative analysis was conducted first, followed by qualitative inquiry to explore the statistical findings. The research was conducted at KPU Bea Cukai Tipe B Batam. The population consisted of 137 employees, all of whom were included in the questionnaire survey through census sampling.

Quantitative data were collected using a five-point Likert questionnaire. A pilot test involving 30 respondents indicated that all items met the stated validity criterion of an item correlation greater than 0.30 and the reliability criterion of Cronbach's alpha greater than 0.60. The main analysis used partial least squares structural equation modeling (PLS-SEM) in SmartPLS 4.0. Measurement model assessment considered indicator loadings, convergent validity, discriminant validity, and internal consistency. Structural assessment considered explained variance, collinearity, path coefficients, and direct and indirect effects.

Hypotheses were tested using bootstrapping with 5,000 subsamples. The stated significance criteria were a t statistic greater than 1.96 and a p value below .05. Qualitative data were collected through in-depth interviews with five key informants and a focus group discussion. The qualitative material was analyzed thematically to support triangulation and interpretation of the quantitative findings.

RESULTS AND DISCUSSION

Measurement Model Assessment

The initial measurement model included 50 indicators, with ten indicators for each construct. Their loadings ranged from .424 to .835 (Table 1). The subsequent model retained 15 indicators: three for digital transformation, one for employee performance, one for service innovation, eight for technology literacy, and two for work effectiveness. The retained loadings are shown in bold in Table 3.

Table 1. Initial indicator loadings

Item no.	DT	EP	SI	TL	WE
1	0.733	0.706	0.615	0.693	0.604
2	0.655	0.684	0.679	0.800	0.640
3	0.579	0.692	0.675	0.710	0.424
4	0.665	0.622	0.671	0.670	0.632
5	0.742	0.666	0.648	0.824	0.525
6	0.565	0.672	0.732	0.835	0.665
7	0.641	0.690	0.687	0.730	0.704
8	0.687	0.643	0.475	0.742	0.726
9	0.577	0.671	0.542	0.725	0.664
10	0.718	0.568	0.434	0.742	0.687

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Note. DT = digital transformation; EP = employee performance; SI = service innovation; TL = technology literacy; WE = work effectiveness. Item numbers correspond to the original Digital, Perform, Service, Techno, and Work indicator labels.

For the retained multi-item constructs, loadings ranged from .706 to .895. Average variance extracted (AVE) was .650 for digital transformation, .595 for technology literacy, and .775 for work effectiveness. Composite reliability ranged from .848 to .921, while Cronbach's alpha ranged from .710 to .903 for these three constructs. The reported measurement statistics are presented in Table 2.

Table 2. Construct reliability and convergent validity

Construct	Cronbach's α	ρA	Composite reliability	AVE
Digital transformation	0.743	0.802	0.848	0.650
Employee performance	1.000	1.000	1.000	1.000
Service innovation	1.000	1.000	1.000	1.000
Technology literacy	0.903	0.912	0.921	0.595
Work effectiveness	0.710	0.716	0.873	0.775

Note. Employee performance and service innovation each have one retained indicator. Their reported 1.000 values do not establish multi-item internal consistency. AVE = average variance extracted.

The cross-loadings indicate that each retained indicator loads more strongly on its assigned construct than on the other constructs. Final outer loadings and cross-loadings are presented in Table 3. The Fornell–Larcker matrix is presented in Table 4; each diagonal value exceeds the corresponding off-diagonal correlations.

Table 3. Final outer loadings and cross-loadings

Indicator	DT	EP	SI	TL	WE
Digital1	**0.861**	0.220	0.091	0.482	0.368
Digital10	**0.774**	0.103	0.008	0.571	0.280
Digital5	**0.781**	0.151	0.003	0.349	0.179
Perform1	0.205	**1.000**	0.329	0.403	0.409
Service6	0.054	0.329	**1.000**	0.185	0.504
Techno10	0.504	0.252	0.032	**0.737**	0.174
Techno2	0.415	0.327	0.183	**0.806**	0.252
Techno3	0.499	0.266	0.126	**0.706**	0.262
Techno5	0.454	0.260	0.110	**0.832**	0.291
Techno6	0.491	0.280	0.141	**0.825**	0.225
Techno7	0.440	0.391	0.137	**0.760**	0.413
Techno8	0.376	0.285	0.272	**0.748**	0.341
Techno9	0.459	0.361	0.101	**0.749**	0.286
Work7	0.343	0.353	0.384	0.304	**0.865**
Work8	0.298	0.367	0.498	0.361	**0.895**

Note. Bold values are the final outer loadings on the assigned construct. All 15 final indicators are shown. The single-indicator loadings of 1.000 for Perform1 and Service6 are reported as in the model output.

Table 4. Fornell–Larcker criterion

Construct	DT	EP	SI	TL	WE
DT	**0.806**	–	–	–	–
EP	0.205	**1.000**	–	–	–
SI	0.054	0.329	**1.000**	–	–
TL	0.586	0.403	0.185	**0.771**	–
WE	0.362	0.409	0.504	0.379	**0.880**

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Note. Diagonal values are the square roots of AVE; off-diagonal values are construct correlations. A dash denotes the unreported upper triangle.

Structural Model Assessment

The inner variance inflation factor (VIF) values ranged from 1.040 to 1.631 (Table 5), indicating limited overlap among the predictors in the reported structural model. The model summary reports R^2 values of .664 for employee performance and .780 for work effectiveness, with adjusted R^2 values of .642 and .767, respectively (Table 6).

Table 5. Inner variance inflation factors

Predictor	Employee performance	Work effectiveness
Digital transformation	1.631	1.529
Service innovation	1.387	1.040
Technology literacy	1.613	1.579
Work effectiveness	1.614	–

Note. VIF = variance inflation factor. A dash denotes a relationship not specified in the model.

Table 6. Reported coefficients of determination

Outcome	R^2	Adjusted R^2
Employee performance	0.664	0.642
Work effectiveness	0.780	0.767

Note. R^2 = coefficient of determination.

Direct and Indirect Effects

Table 7 presents the direct-effect estimates in hypothesis order. Digital transformation was positively associated with work effectiveness (β = .251, p = .017), as was service innovation (β = .464, p < .001). Technology literacy did not have a significant association with work effectiveness (β = .146, p = .100). Thus, H1 and H2 were supported, whereas H3 was not supported.

Table 7. Direct-effect hypothesis tests

H	Path	β	M	SD	t	p	Decision
H1	DT → WE	0.251	0.241	0.105	2.393	0.017	Supported
H2	SI → WE	0.464	0.465	0.074	6.292	< .001	Supported
H3	TL → WE	0.146	0.155	0.089	1.649	0.100	Not supported
H4	DT → EP	0.085	0.079	0.138	0.620	0.536	Not supported
H5	SI → EP	0.152	0.137	0.091	1.680	0.094	Not supported
H6	TL → EP	0.336	0.345	0.089	3.763	< .001	Supported
H7	WE → EP	0.236	0.239	0.084	2.795	0.005	Supported

Note. β = original sample estimate; M = bootstrap sample mean; SD = bootstrap standard deviation. Values below .001 are reported as p < .001. Decisions use the stated p < .05 criterion.

For employee performance, the direct effects of digital transformation (β = .085, p = .536) and service innovation (β = .152, p = .094) were not significant. Technology literacy (β = .336, p < .001) and work effectiveness (β = .236, p = .005) showed significant positive associations with performance. H6 and H7 were therefore supported, while H4 and H5 were not supported.

Table 8. Specific indirect-effect hypothesis tests

H	Path	β	M	SD	t	p	Decision
H8	DT → WE → EP	0.059	0.056	0.031	1.937	0.053	Not supported
H9	SI → WE → EP	0.109	0.112	0.047	2.321	0.021	Supported
H10	TL → WE → EP	0.035	0.037	0.026	1.324	0.186	Not supported

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Note. The indirect paths are evaluated separately from their component direct paths. A significant component path does not by itself establish a significant indirect effect.

The indirect effect of service innovation on employee performance through work effectiveness was significant (β = .109, p = .021), supporting H9. The indirect effects for digital transformation (β = .059, p = .053) and technology literacy (β = .035, p = .186) were not significant, so H8 and H10 were not supported. These estimates support mediation for service innovation only; they do not support a general claim that work effectiveness mediates all three relationships.

Discussion and Qualitative Interpretation

The association between digital transformation and work effectiveness suggests that digital systems contribute to how employees organize and complete their tasks. Nevertheless, neither the direct performance path nor the indirect path through work effectiveness met the stated significance threshold. Digital adoption should therefore be assessed through observable changes in work practices, rather than assumed to improve every performance outcome. This interpretation is consistent with the broader view of digital transformation as organizational change, rather than technology installation alone (Vial, 2019).

Service innovation showed a significant association with work effectiveness and a significant indirect relationship with employee performance. The results suggest that changes in service delivery contribute to performance through more effective work processes. This interpretation accords with the emphasis on implementing service innovations and creating value through improved service practices (den Hertog et al., 2010; Helkkula et al., 2018). Since the direct service innovation path was not significant, the results should not be characterized as partial mediation.

Technology literacy was significantly associated with employee performance but not with work effectiveness. Employees' digital capabilities may support the execution of their responsibilities without operating through the particular work-effectiveness measure used in this model. This result is compatible with the multidimensional view of technology literacy, which encompasses technical, cognitive, and social capabilities (Ng, 2012). The lack of a significant indirect effect should not be interpreted as evidence that technology skills are unimportant.

The interview and focus group accounts emphasized that introducing CEISA and e-Office does not automatically improve output when employees continue to work slowly or have difficulty using technology. Timely completion of customs documents and fewer procedural errors were described as practical conditions for translating digital systems into productive service delivery. These qualitative observations help explain the importance of effective work processes, although they do not replace the separate significance tests for the model's indirect effects.

The findings have practical implications for the office's management. Continuing technology-literacy training can address differences in employees' digital skills, while fuller integration of CEISA can reduce duplicate manual data entry. Service innovation should also incorporate employee input so that procedural improvements respond to operational conditions in the Batam Free Trade Zone. The single-indicator measures of service innovation and employee performance limit the breadth of those constructs and should be considered when interpreting the findings.

CONCLUSION

The reported hypothesis tests indicate that digital transformation and service innovation are positively associated with work effectiveness, while technology literacy and work effectiveness are positively associated with employee performance. The direct effects of digital transformation and service innovation on performance were not significant, and technology literacy was not significantly associated with work effectiveness. Work effectiveness significantly mediated the relationship between service innovation and employee performance, but not the corresponding relationships for digital transformation or technology literacy.

Management should combine continuing digital-skills development with system integration and service improvements that strengthen everyday work processes. The Directorate General of Customs and Excise can support service innovations that incorporate operational input from employees. Future research may extend the model by examining digital organizational culture or transformational leadership and by strengthening the measurement of service innovation and employee performance.

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