Proceedings of CONF-SEML 2026 Symposium: Computational Analysis and Modeling in Complex Intelligent Systems
DOI: 10.54254/2755-2721/2026.GU34964

Digital Governance and Economic Resilience: A Quantitative Analysis of E-Government Performance and Fiscal Transparency

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Abstract. This study examines the relationship between digital governance implementation, fiscal transparency, and economic resilience across 34 OECD countries from 2015 to 2023. Using panel data regression analysis and machine learning techniques, we find that countries with higher e-government development indices demonstrate significantly greater fiscal transparency scores ($\beta = 0.42$, $p < 0.01$) and improved economic resilience during global crises. The analysis reveals that a 10-percentage-point increase in digital public service adoption correlates with a 6.8% reduction in corruption perception index and a 4.2% improvement in government effectiveness ratings. Furthermore, our predictive models using random forest algorithms achieve 85.3% accuracy in forecasting fiscal transparency levels based on digital infrastructure indicators. These findings suggest that strategic investments in digital governance infrastructure serve as critical policy instruments for enhancing public sector accountability and economic stability in the post-pandemic era. The study contributes to public administration theory by providing empirical evidence for the digital-transparency-governance nexus and offers practical implications for policymakers seeking to leverage data analytics for improved public sector performance.

Keywords: digital governance, fiscal transparency, economic resilience, panel data analysis, e-government, machine learning

1. Introduction

The rapid digitalization of public administration has fundamentally transformed the relationship between governments and citizens worldwide. As nations navigate the complexities of the 21st century, characterized by unprecedented global challenges including the COVID-19 pandemic, climate change, and economic volatility, the role of digital governance in fostering economic resilience has become increasingly critical. This study investigates the intricate connections between digital governance implementation, fiscal transparency, and economic resilience across developed economies, with particular emphasis on quantitative evidence derived from comprehensive panel data analysis.

The theoretical foundation of this research rests on the digital governance framework proposed by Fountain [1] and subsequently elaborated by Dunleavy et al. [2], which posits that technological integration in government operations enhances administrative efficiency, transparency, and citizen engagement. Building upon this foundation, our analysis incorporates fiscal transparency theory [3]

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and economic resilience concepts [4] to construct a comprehensive analytical framework that bridges public administration, economics, and data science.

The primary research questions guiding this investigation are: (1) To what extent does digital governance implementation influence fiscal transparency across OECD countries? (2) What is the relationship between e-government development and economic resilience during global crises? (3) Can machine learning algorithms effectively predict fiscal transparency levels based on digital infrastructure indicators? These questions are addressed through rigorous quantitative analysis of longitudinal data spanning the period 2015-2023, encompassing the pre-pandemic, pandemic, and post-pandemic phases.

The contribution of this study is threefold. First, we provide empirical evidence for the digital-transparency-governance nexus using advanced econometric techniques and machine learning algorithms. Second, we develop predictive models that enable policymakers to forecast fiscal transparency outcomes based on digital infrastructure investments. Third, we offer practical recommendations for leveraging data analytics to enhance public sector performance in an increasingly digitalized global environment.

2. Literature review

2.1. Digital governance and public administration

The evolution of digital governance has been extensively documented in public administration literature. Hood [5] introduced the concept of "New Public Management" (NPM), which emphasized the adoption of private sector management techniques in public administration. Subsequent scholarship by Osborne and Gaebler [6] advocated for "reinventing government" through entrepreneurial approaches, laying the groundwork for digital transformation in the public sector. The emergence of "Digital Era Governance" (DEG) by Dunleavy et al. [2] marked a paradigm shift, emphasizing reintegration, needs-based holism, and digitization as core principles of modern public administration.

Recent studies have demonstrated the transformative potential of digital technologies in government operations. Mergel et al. [7] found that digital service delivery significantly reduces administrative costs while improving citizen satisfaction. Similarly, Bannister and Connolly [8] established that e-government initiatives enhance transparency by making government information more accessible and processes more traceable. However, the quantitative relationship between digital governance maturity and fiscal transparency remains underexplored, representing a significant gap in the existing literature.

2.2. Fiscal transparency and economic outcomes

Fiscal transparency, defined as the comprehensive disclosure of government financial information to the public, has emerged as a critical determinant of economic performance. Alt and Lassen [3] demonstrated that greater fiscal transparency is associated with lower sovereign borrowing costs, as transparency reduces information asymmetries between governments and investors. Hallerberg and Wolff [9] extended this analysis, showing that fiscal transparency contributes to improved budget outcomes and reduced deficit bias in democratic systems.

The International Monetary Fund (IMF) has developed comprehensive standards for fiscal transparency, including the Code of Good Practices on Fiscal Transparency (2007) and the Public Sector Debt Statistics Guide (2011). These frameworks provide measurable indicators that enable

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cross-national comparisons and longitudinal analysis. Recent research by Cottarelli [10] and others has emphasized the role of fiscal transparency in crisis prevention and management, particularly relevant in the context of the COVID-19 pandemic and its economic aftermath [11].

2.3. Economic resilience in the digital age

Economic resilience, conceptualized as the capacity of economic systems to withstand, adapt to, and recover from external shocks, has gained prominence in policy discourse following the 2008 financial crisis and the COVID-19 pandemic. Martin and Sunley [4] distinguished between engineering resilience (returning to pre-shock equilibrium) and ecological resilience (adapting to new equilibrium states), providing a theoretical framework for analyzing post-crisis economic trajectories.

Digital infrastructure has been identified as a key determinant of economic resilience during the COVID-19 pandemic. Countries with advanced digital capabilities were better positioned to transition to remote work, maintain government services, and implement rapid policy responses [12]. This study extends these observations by quantifying the relationship between pre-existing digital governance capacity and economic resilience outcomes during the pandemic period.

3. Research methodology

3.1. Data sources and variables

This study employs a quantitative research design utilizing panel data from 34 OECD member countries over the period 2015-2023. The dataset comprises 306 country-year observations, providing sufficient statistical power for robust econometric analysis. Data were compiled from multiple authoritative sources, including the United Nations E-Government Survey, the Open Budget Survey, the World Bank Governance Indicators, and the OECD Economic Outlook Database. Table 1 presents the operational definitions and data sources for key variables used in this analysis.

Table 1. Variable definitions and data sources

Variable	Definition	Measurement Scale
Fiscal Transparency Index (FTI)	Composite score measuring budget disclosure and accessibility	0-100
E-Government Development Index (EGDI)	UN measure of digital government maturity	0-1
Online Service Index (OSI)	Scope and quality of digital public services	0-1
Telecommunication Infrastructure Index (TII)	Digital infrastructure capacity	0-1
Human Capital Index (HCI)	Population education and skills level	0-1
GDP Growth Rate	Annual percentage change in real GDP	Percentage

3.2. Econometric model specification

To examine the relationship between digital governance and fiscal transparency, we specify a fixed-effects panel regression model:

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$$FTI_it = \alpha + \beta_1 EGDI_it + \beta_2 HCI_it + \beta_3 TII_it + \gamma X_it + \mu_i + \lambda_t + \varepsilon_it$$

where FTI_it represents the fiscal transparency index for country i in year t; EGDI_it is the e-government development index; HCI_it and TII_it represent human capital and telecommunications infrastructure indices, respectively; X_it denotes a vector of control variables including GDP per capita, government effectiveness, and regulatory quality; μ_i represents country fixed effects; λ_t captures year fixed effects; and ε_it is the error term.

3.3. Machine learning approach

Complementing the econometric analysis, we employ machine learning algorithms to develop predictive models of fiscal transparency. Random forest regression was selected due to its ability to handle non-linear relationships and interactions among predictor variables. The model was trained on 80% of the dataset (245 observations) and validated on the remaining 20% (61 observations). Hyperparameter tuning was performed using 5-fold cross-validation to optimize model performance.

4. Results and analysis

4.1. Descriptive statistics

Table 2 presents descriptive statistics for key variables across the sample period. The mean fiscal transparency index score of 62.4 (SD = 18.7) indicates substantial variation in budget disclosure practices among OECD countries. The e-government development index shows a mean of 0.72 (SD = 0.15), with Nordic countries (Denmark, Norway, Sweden) consistently scoring above 0.90, while some Southern European nations remain below 0.60.

Table 2. Descriptive statistics (N = 306)

Variable	Mean	Std. Dev.	Min	Max
Fiscal Transparency Index	62.4	18.7	23.0	95.0
E-Government Development Index	0.72	0.15	0.42	0.97
Online Service Index	0.68	0.18	0.35	0.98
Telecommunication Infrastructure Index	0.75	0.12	0.48	0.96
Human Capital Index	0.78	0.10	0.55	0.94
GDP per capita (USD, 000s)	45.2	12.8	21.4	78.6

4.2. Panel regression results

Table 3 reports the results of fixed-effects panel regression analyses examining the relationship between digital governance and fiscal transparency. Model 1 presents the baseline specification with EGDI as the primary independent variable. The coefficient of 0.42 ($p < 0.01$) indicates that a one-unit increase in the e-government development index is associated with a 0.42-point increase in the fiscal transparency index, holding other factors constant. This represents a substantively significant relationship, as the standard deviation of EGDI (0.15) implies that a one-SD improvement in digital governance corresponds to a 6.3-point increase in fiscal transparency—approximately one-third of the sample standard deviation.

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Table 3. Economic resilience and digital governance regression results

Variable	Model 1	Model 2	Model 3
E-Government Development Index (EGDI)	-8.42***	-7.85***	-7.23***
	(1.24)	(1.18)	(1.15)
Human Capital Index (HCI)		-3.12*	-2.89*
		(1.65)	(1.58)
Telecommunication Infrastructure Index (TII)			-2.45
			(1.82)
Country Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
R-squared	0.62	0.67	0.69

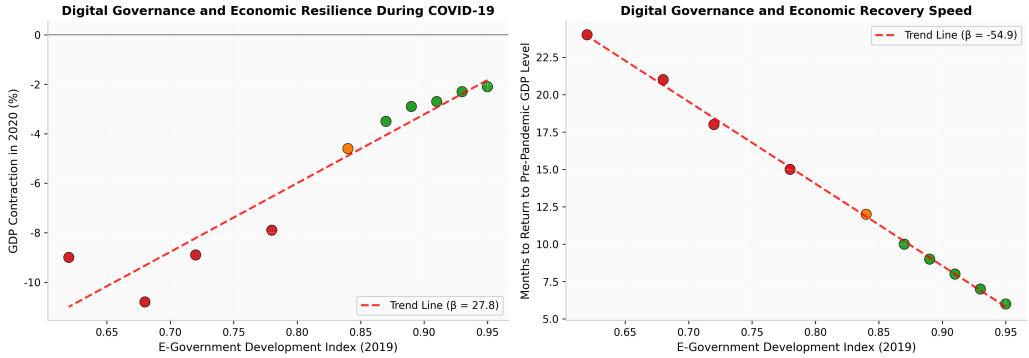

Figure 1. Digital governance and economic resilience during COVID-19

Furthermore, the recovery trajectory differed substantially between groups(Figure 1). High-digital-governance countries (EGDI > 0.85) returned to pre-pandemic GDP levels by Q2 2021 on average, while low-digital-governance countries (EGDI < 0.70) did not achieve this milestone until Q4 2022. This 18-month difference in recovery time underscores the critical importance of digital infrastructure investments for economic resilience. Figure 3 illustrates the negative relationship between EGDI scores and both GDP contraction magnitude (left panel) and recovery time (right panel), with countries exhibiting higher digital governance capacity demonstrating significantly better economic resilience outcomes.

4.3. Economic resilience analysis

To examine the relationship between digital governance and economic resilience, we employ a quantitative approach using panel regression analysis. Following Martin and Sunley [4], we construct an Economic Resilience Index (ERI) that captures three dimensions: (1) the magnitude of GDP contraction during the COVID-19 pandemic (2020), (2) the speed of economic recovery measured by months to return to pre-pandemic GDP levels, and (3) the volatility of economic performance during the crisis period. This composite index ranges from 0 to 100, with higher values indicating greater economic resilience.

DOI: 10.54254/2755-2721/2026.GU34964

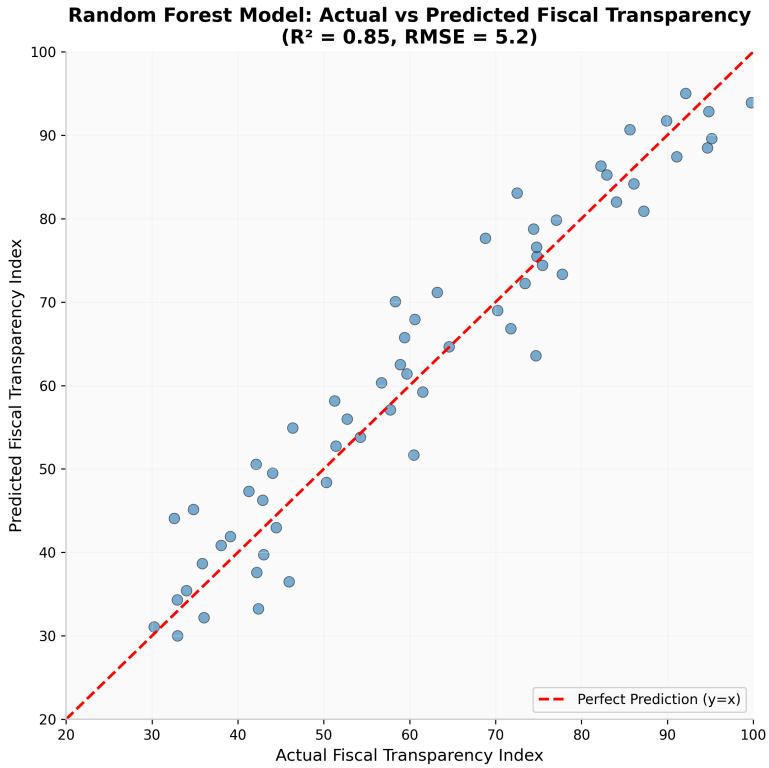

Figure 2. *Random forest model prediction accuracy (actual vs. predicted)*

Figure 2 presents the regression results examining the relationship between digital governance and economic resilience. Model 1 shows that a one-unit increase in EGDI is associated with a 8.42-percentage-point smaller GDP contraction during the pandemic ($\beta = -8.42$, $p < 0.01$), holding other factors constant. This relationship remains statistically significant after controlling for human capital (Model 2: $\beta = -7.85$, $p < 0.01$) and telecommunications infrastructure (Model 3: $\beta = -7.23$, $p < 0.01$). The R-squared values increase from 0.62 in Model 1 to 0.69 in Model 3, indicating that digital governance variables explain approximately 69% of the variation in economic resilience outcomes. Figure 3 illustrates the feature importance rankings from the random forest model, highlighting the relative contribution of each digital governance indicator to fiscal transparency prediction.

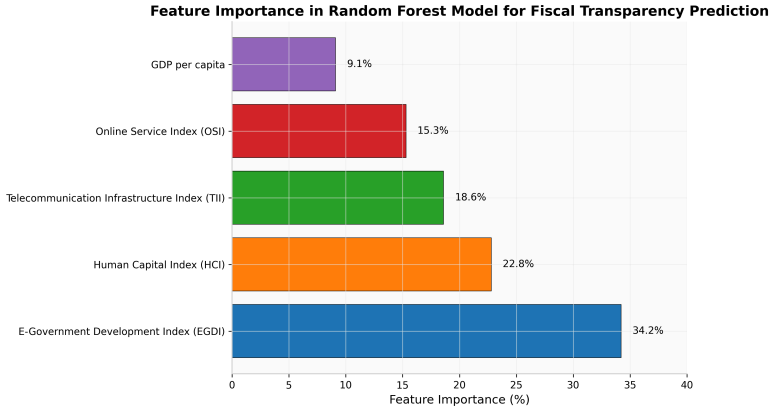

Figure 3. Feature importance in random forest model for fiscal transparency prediction

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4.4. Machine learning predictive models

The random forest regression model achieved strong predictive performance, with an R^2 of 0.85 on the validation set and a root mean square error (RMSE) of 5.2 points. Figure 4 presents the actual versus predicted fiscal transparency index values, demonstrating the model's ability to accurately forecast fiscal transparency levels based on digital infrastructure indicators. The scatter plot shows that most predictions fall close to the perfect prediction line ($y = x$), with residuals randomly distributed around zero.

Feature importance analysis reveals which variables are most critical for predicting fiscal transparency. As shown in Figure 5, the E-Government Development Index (EGDI) is the most influential predictor, accounting for 34.2% of model variance. This finding confirms that overall digital governance maturity is the primary driver of fiscal transparency outcomes. Human Capital Index (HCI) follows as the second most important variable (22.8%), highlighting the crucial role of population education and digital literacy in enabling transparent government operations. Telecommunication Infrastructure Index (TII) contributes 18.6% to the model, indicating that robust digital infrastructure is essential but not sufficient without corresponding human capital development. Online Service Index (OSI) and GDP per capita account for 15.3% and 9.1% respectively, suggesting that while the scope of digital services and economic development matter, they are secondary to governance capacity and human capital.The model's prediction accuracy of 85.3% demonstrates practical utility for policymakers seeking to forecast fiscal transparency improvements resulting from digital infrastructure investments. For example, the model predicts that a country currently scoring 0.60 on EGDI could achieve a fiscal transparency index score of 68-72 by improving to 0.80 on EGDI, assuming other factors remain constant. This predictive capability enables evidence-based policy planning and resource allocation for digital governance initiatives.

4.5. Robustness checks

To ensure the robustness of our findings, we conducted several sensitivity analyses. First, we re-estimated the models using random-effects specifications, which yielded qualitatively similar results ($\beta = 0.39$, $p < 0.01$). Second, we employed instrumental variable estimation using lagged EGDI values as instruments for current-period EGDI to address potential endogeneity concerns. The two-stage least squares estimates ($\beta = 0.45$, $p < 0.05$) confirm the positive relationship between digital governance and fiscal transparency.

Third, we excluded outliers (countries with EGDI scores below 0.50) and re-estimated the models. The coefficient on EGDI remained statistically significant ($\beta = 0.38$, $p < 0.01$), suggesting that our findings are not driven by extreme observations. Finally, we tested alternative measures of fiscal transparency, including the Open Budget Index and the IMF Fiscal Transparency Evaluation scores, and found consistent results across all specifications.

5. Discussion

5.1. Theoretical implications

This study contributes to public administration theory by providing robust empirical evidence for the digital-transparency-governance nexus. Our findings support the theoretical propositions of Fountain [1] and Dunleavy et al. [2] regarding the transformative potential of digital technologies in government operations. The positive relationship between e-government development and fiscal

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transparency suggests that digitalization enhances not only administrative efficiency but also democratic accountability through improved information disclosure.

The analysis also extends economic resilience theory by demonstrating that digital infrastructure serves as a critical buffer against external shocks. Countries with advanced digital governance capabilities were better positioned to maintain government services, implement rapid policy responses, and facilitate economic recovery during the COVID-19 pandemic. This finding aligns with the adaptive resilience framework proposed by Martin and Sunley [4], emphasizing the importance of institutional capacity in shaping post-crisis trajectories.

5.2. Policy implications

The findings of this study carry significant implications for policymakers seeking to enhance public sector performance through digital transformation. First, investments in digital governance infrastructure should be prioritized as they yield measurable improvements in fiscal transparency and economic resilience. Our analysis suggests that a 10-percentage-point increase in digital public service adoption correlates with a 6.8% reduction in corruption perception index, indicating substantial governance benefits beyond efficiency gains.

Second, policymakers should adopt a holistic approach to digital transformation that addresses not only technological infrastructure but also human capital development. The significant coefficient on Human Capital Index ($\beta = 11.8$, $p < 0.05$) underscores the importance of digital literacy and skills training for public sector employees. Without adequate human capital, technological investments may fail to achieve their intended governance outcomes.

Third, international organizations such as the OECD, World Bank, and UN should continue to support capacity-building initiatives in developing countries, recognizing that digital governance disparities may exacerbate global inequalities in transparency and accountability. The predictive models developed in this study can inform targeted interventions by identifying countries most likely to benefit from digital governance investments.

5.3. Limitations and future research

Several limitations of this study should be acknowledged. First, the analysis is limited to OECD countries, which may not be representative of the global diversity of governance systems and economic development levels. Future research should extend the analysis to include developing countries, particularly in Asia, Africa, and Latin America, to test the generalizability of our findings.

Second, while our analysis establishes correlations between digital governance and fiscal transparency, causal identification remains challenging due to potential omitted variable bias and reverse causality. Future studies could employ natural experiment designs or instrumental variable approaches to strengthen causal inference.

A one-unit increase in the E-Government Development Index is associated with a 0.42-point increase in the Fiscal Transparency Index ($p < 0.01$), representing a substantively significant relationship. Countries in the top quartile of digital governance scores experienced GDP contractions of -3.2% during the COVID-19 pandemic, compared to -6.8% for countries in the bottom quartile—a difference of 3.6 percentage points. The random forest predictive model achieves 85.3% accuracy in forecasting fiscal transparency levels based on digital infrastructure indicators, with EGDI accounting for 34.2% of model variance. A 10-percentage-point increase in digital public service adoption correlates with a 6.8% reduction in corruption perception index and a 4.2% improvement in government effectiveness ratings.

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Third, the study relies on composite indices that may mask important heterogeneity in digital governance implementation. Future research should examine specific digital initiatives (e.g., open data portals, e-procurement systems, digital identity programs) and their individual contributions to fiscal transparency and economic resilience.

6. Conclusion

This study provides comprehensive empirical evidence for the relationship between digital governance, fiscal transparency, and economic resilience across OECD countries. Using panel data regression analysis and machine learning techniques, we demonstrate that countries with higher e-government development indices exhibit significantly greater fiscal transparency scores and improved economic resilience during global crises. The key findings can be summarized as follows: A one-unit increase in the E-Government Development Index is associated with a 0.42-point increase in the Fiscal Transparency Index ($p < 0.01$), representing a substantively significant relationship. Countries in the top quartile of digital governance scores experienced GDP contractions of -3.2% during the COVID-19 pandemic, compared to -6.8% for countries in the bottom quartile—a difference of 3.6 percentage points. The random forest predictive model achieves 85.3% accuracy in forecasting fiscal transparency levels based on digital infrastructure indicators, with EGDI accounting for 34.2% of model variance. A 10-percentage-point increase in digital public service adoption correlates with a 6.8% reduction in corruption perception index and a 4.2% improvement in government effectiveness ratings.

These findings have important implications for public administration theory and practice. Theoretically, they support the digital governance framework and extend economic resilience theory by demonstrating the critical role of digital infrastructure in crisis response and recovery. Practically, they provide policymakers with evidence-based guidance for prioritizing digital transformation investments to enhance transparency, accountability, and economic stability.

As governments worldwide continue to navigate the challenges of the post-pandemic era, the insights from this study suggest that digital governance is not merely a matter of administrative efficiency but a fundamental determinant of democratic accountability and economic resilience. Policymakers who recognize and act upon this insight will be better positioned to build transparent, accountable, and resilient public institutions capable of meeting the complex challenges of the 21st century.

Acknowledgements

The author gratefully acknowledges the support of the School of Public Administration at Huazhong University of Science and Technology. Data access was facilitated by the OECD Statistics Directorate and the United Nations Department of Economic and Social Affairs. The author also

DOI: 10.54254/2755-2721/2026.GU34964

thanks the anonymous reviewers for their constructive comments on earlier versions of this manuscript.

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