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Synergy between Artificial Intelligence and Good Governance: Deciphering Predictive Dynamics for Optimal Public Performance in Morocco

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ABSTRACT

This paper explores the synergistic impact of machine learning and good governance principles on improving the performance of the Moroccan public sector. By mobilizing multidimensional data (audit reports, satisfaction surveys, administrative data) and advanced algorithms (Random Forests, SVM), the study assesses how the pillars of governance - transparency, accountability, leadership, innovation, ethics and sustainable development - influence institutional effectiveness, service quality and user satisfaction. The results reveal that Random Forests significantly outperform SVM in predictive accuracy, thanks to their ability to model non-linear and complex relationships. Transparency and accountability emerge as the key determinants of performance, acting directly on institutional credibility and civic engagement. The other pillars, while relevant, operate mainly via indirect mechanisms or systemic synergies, underlining the need for an integrated approach. Visualizations (correlation matrices, interaction maps) confirm the interdependence of variables and the centrality of the two priority pillars. On a theoretical level, this research validates the contribution of artificial intelligence to deciphering governance dynamics, enriching existing conceptual models. In practical terms, it argues for greater investment in the digitization of decision-making processes, training in data analysis tools and the strengthening of accountability systems. Future prospects include the exploration of emerging AI models (Deep learning), longitudinal analysis of reforms and cross-national comparative studies. This work contributes to an empirical understanding of the levers of effective public governance, aligned with the challenges of socio-economic development in Morocco.

Keywords: Machine Learning, Good Governance, Public Sector Performance, Predictive Analytics, Administrative Reform
JEL Classifications: H11, H83, C45

1. INTRODUCTION

The rapid evolution of digital technologies has brought about a profound transformation of many business sectors, and organizational management is no exception. Machine learning (ML), in particular, is emerging as an essential tool, capable of extracting relevant information from large datasets and significantly improving decision-making (Jordan and Mitchell, 2015). ML algorithms, whether supervised, unsupervised or reinforcement-based, offer innovative perspectives for analyzing complex problems and optimizing operational processes, whether in the private (Waller and Fawcett, 2013) or public (Anastasopoulos and Whitford, 2019) sectors. This ability to identify patterns, make predictions and automate tasks enables organizations to increase their efficiency and responsiveness in the face of constantly changing environments. In this context, integrating ML into management becomes not only a competitive advantage, but also a strategic necessity to ensure the sustainability and development of organizations.

Alongside these technological advances, the public sector continues to face major performance challenges. The increasing demands of citizens in terms of service quality, transparency and accountability mean that the ways in which public institutions operate are constantly being called into question (Behn, 2003). In addition, the complexity of socio-economic and environmental

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issues demands rapid adaptation and optimal use of public resources. Against this backdrop of tensions and transformations, it is imperative to explore ways of improving public sector performance, taking into account the interplay between external factors (stakeholder demands) and internal factors (management methods).

Good governance is a fundamental part of this equation. Indeed, a set of key principles such as transparency, accountability, participation, innovation, ethics and sustainable development are the foundations on which successful and legitimate public institutions can be built (Bovens, 2007; Grindle, 2007). The adoption of good governance practices is essential to establish a climate of trust between citizens and their institutions, to optimize the use of public resources and to guarantee the effectiveness of the services provided (Kooiman, 2003). It is therefore crucial to better understand how the different pillars of good governance can interact to influence public sector performance, with a view to continuous improvement.

However, despite the recognized importance of good governance and the promising potential of ML, there remains a lack of in-depth research into the combined impact of these two elements on public sector performance, particularly in the Moroccan context. Existing literature focuses either on the isolated study of good governance and its impact (Taibi and Benabdelhadi, 2020), or on ML applications in different areas of management, but without really exploring their synergy for an overall improvement in public sector performance. Moreover, studies that have explored this synergy in other geographical or sectoral contexts often present methodological shortcomings. These include the complexity of data sets, the diversity of approaches to performance evaluation, and the lack of a holistic approach integrating all the pillars of good governance. This situation warrants further research to empirically and rigorously identify the mechanisms of interaction between good governance and machine learning, and to understand the concrete benefits for public organizations.

This observation leads us to pose the central question of this research: "How can machine learning techniques help us better understand and optimize the impact of good governance principles on the performance of Moroccan public institutions?". To answer this question, this study sets itself the following objectives: (1) Assess the importance of the different pillars of good governance (transparency, accountability, leadership, innovation, ethics and sustainable development) on the performance of Moroccan public organizations. (2) Determine the most appropriate machine learning algorithms for analyzing complex data related to governance and public sector performance. (3) Develop predictive models capable of quantifying the impact of good governance practices on organizational performance. (4) Formulate concrete and operational recommendations for improving public management practices in Morocco, based on empirical evidence.

The present study stands out for its unique contribution to the existing literature. Firstly, it proposes an innovative combination of the field of good governance and machine learning, in order to assess in greater detail the impact of the former on public sector performance. Secondly, this study focuses on the Moroccan context, a field of investigation that remains little explored in this field of research. Finally, it provides models and analytical tools for identifying and assessing the impact of governance levers on the performance of public organizations. On a practical level, this study aims to provide valuable information to public sector decision-makers, enabling them to identify the most effective and relevant good governance practices in the Moroccan context. The results of this research will also serve to guide future reforms, optimize resource allocation and ensure greater efficiency and transparency in public services. The combination of a rigorous theoretical approach and an advanced data analysis methodology will thus shed new and concrete light on how machine learning can support public sector performance.

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

This section aims to establish a sound theoretical framework for our study, by clarifying key concepts and critically reviewing existing literature. We will discuss the definitions of good governance, public sector performance, and the different forms of machine learning. Next, we will review relevant studies on the relationship between good governance and performance, on the applications of machine learning in management, and on the few works that explore the intersection of these two fields. Finally, we will synthesize the main findings and position our study in relation to the literature.

2.1. Key Definitions and Concepts

- Good governance: Good governance is a multidimensional concept that refers to the processes and institutions by which decisions are made and implemented in organizations (Bovens, 2007). It transcends mere administrative mechanisms and encompasses fundamental values and principles that guide public action. In this study, we will adopt a definition based on the work of the World Bank (2018), which highlights six essential pillars:
    - Transparency: Access to information and open communication of public decisions and policies, enabling greater citizen oversight (Heald, 2006).
    - Accountability: The obligation of public officials to account for their actions and the results obtained, by ensuring the existence of effective control mechanisms (Mulgan, 2000).
    - Leadership: The ability of decision-makers to inspire, motivate and steer public organizations towards clear, ambitious goals, fostering a shared vision and collective commitment (Bass, 1990).
    - Innovation: The search for and adoption of new solutions and practices to improve public services and meet contemporary challenges (Osborne and Gaebler, 1992).
    - Ethics: Adherence to high standards of professional conduct and the fight against corruption, in order to guarantee the integrity and impartiality of public action (Frederickson, 1997).
    - Sustainable development: The integration of environmental and social concerns into public policy and practice to

ensure a just and viable future for generations to come (WCED, 1987).

- Public sector performance: Public sector performance is a complex notion that encompasses several dimensions. We will adopt a multidimensional approach that takes into account the following factors (Van Dooren et al., 2010):
  - Efficiency: The ability of public organizations to achieve their objectives by making optimal use of available resources (Bozeman, 2007).
  - Service quality: The ability of public services to meet the needs and expectations of users, in terms of accessibility, relevance and reliability (Parasuraman et al., 1988).
  - User satisfaction: The level of citizens' satisfaction and confidence in public services, reflecting the perceived efficiency and quality of services (Oliver, 1997).
  - Operational efficiency: The optimization of internal processes for the production of services, in terms of costs and lead times (Likierman, 2016).
  - Socio-economic impact: The impact of public policies on people's living conditions and economic and social development (Campbell, 2015).
- Machine learning: Machine learning (ML) is a branch of artificial intelligence that enables computers to learn from data, without being explicitly programmed (Mitchell, 1997). ML algorithms can be grouped into three main categories (Goodfellow et al., 2016):
  - Supervised learning: The algorithm learns from a labeled data set, where the target variable is known (Hastie et al., 2009). Typical tasks are classification and regression.
  - Unsupervised learning: The algorithm learns from unlabeled data, in order to identify patterns or structures (Bishop, 2006). Typical tasks are clustering and dimension reduction.
  - Reinforcement learning: The algorithm learns through interactions with an environment, receiving rewards or penalties based on its actions (Sutton and Barto, 2018).

2.2. Analysis of Existing Literature

- Governance and performance: The relationship between good governance and organizational performance has been extensively studied in the context of the public sector (Andrews and Entwistle, 2010). Theoretical and empirical studies emphasize the importance of transparency, accountability and participation mechanisms in guaranteeing the legitimacy of institutions and optimizing their operation (Kooiman, 2003; Moynihan and Pandey, 2007). Other studies highlight the importance of enlightened leadership and a culture of innovation in improving service quality and process efficiency (Osborne and Gaebler, 1992). On the other hand, empirical studies show mixed results, depending on institutional contexts, performance measures used and methodologies employed (Pollitt and Bouckaert, 2017). Moreover, most of these studies do not incorporate the impact of technological factors such as machine learning into their analyses.
- Machine learning and management: Machine learning has established itself as an essential tool in many areas of management, particularly for prediction, classification, optimization and decision-making (Davenport and Ronanki, 2018). Several studies show the effectiveness of ML for financial analysis, supply chain optimization, customer relationship management, and human resources management (Waller and Fawcett, 2013; Hasan, 2022). In addition, predictive analytics based on machine learning techniques enable organizations to anticipate trends and optimize their business processes (Shmueli and Koppius, 2011). Nevertheless, ML applications in the public sector remain limited, notably due to the peculiarities of this sector (complexity of missions, budget constraints, etc.) and a lack of structured, exploitable data.
- The intersection: Some recent work has explored the combination of machine learning and governance, but mainly in the private sector (Visani et al., 2023). For example, some studies have used ML to identify the governance factors that most influence corporate financial performance (Zhao et al., 2023). Others have looked at the relationship between governance practices and social responsibility (Diamastuti et al., 2021), or at the role of ML in improving transparency in the public sector (Taddeo and Floridi, 2016) However, these studies are rare and do not allow results to be generalized to all contexts. In addition, there is a lack of research focusing on the application of machine learning to improve governance and public sector performance, particularly in developing countries such as Morocco.

2.3. Summary and Positioning

The literature review highlighted the importance of good governance for the performance of public organizations, as well as the potential of machine learning to optimize management processes and decision-making. However, there remains a lack of studies that combine these two fields of research, in order to assess the impact of good governance practices on the performance of public institutions through ML techniques. Existing studies generally focus on isolated aspects of governance or ML, and fail to integrate the complex interactions between the different pillars of good governance and their effect on organizational performance. The present study aims to fill this gap, by exploring the combination of good governance and machine learning techniques, applying this approach to a specific context (Morocco), and using a rigorous methodology to empirically quantify the links between these concepts. In other words, our approach stands out for its unique combination of ML and good governance analysis, and its application in the Moroccan context. It enriches the body of knowledge by offering an empirical perspective based on the application of advanced methods for the analysis of public data and an in-depth understanding of the mechanisms of interaction between good governance and public sector performance.

3. METHODOLOGY

This section details the methodology employed to study the impact of good governance practices on the performance of Moroccan public institutions, using machine learning techniques. We will describe the data collection, the pre-processing process, the ML algorithms used, as well as the model evaluation methods.

3.1. Data Collection

For this study, we combined several data sources to obtain a comprehensive and in-depth view of the governance and performance of Moroccan public institutions. Our database consists of 500 observations from the following sources:

- Audit reports: Reports produced by external control and audit bodies (Cour des Comptes, Inspection Générale des Finances, etc.) were used to extract objective, verifiable information on compliance with governance standards, procedures in place, and any malfunctions observed. These reports provided us with data on transparency, accountability and organizational ethics.
- User satisfaction surveys: These surveys, conducted by public institutions or independent bodies, provided information on citizens' perceptions of the quality of public services, in terms of accessibility, speed, efficiency and overall satisfaction. We also extracted data on citizens' level of trust in institutions.
- Administrative sources: Data from public administrations (statistical databases, activity reports, strategic plans, etc.) were used to collect quantitative (e.g., target achievement rates, processing times, operating costs) and qualitative (e.g., level of innovation, staff commitment) performance indicators.

The sampling process was stratified to guarantee the representativeness of our database. We randomly selected public institutions of different sizes, from different sectors (health, education, infrastructure, general administration, etc.) and from different regions of Morocco. This approach enabled us to minimize bias and generalize the results to the entire Moroccan public sector. The data collected covers a 5-year period (2018-2022), enabling analysis of temporal dynamics and trends.

The data collected to assess governance is made up of indicators for each pillar, developed from the sources cited. The indicators used are as follows:

- Transparency: Degree of publication of public information, accessibility of documents, frequency of public reporting
- Accountability: Number of control mechanisms, follow-up of control body recommendations, level of accountability of stakeholders
- Leadership: Level of commitment of leaders, strategic vision, ability to mobilize resources
- Innovation: Implementation of new procedures, ability to adapt the organization to change, participation in innovative projects
- Ethics: Compliance with codes of conduct, level of corruption, anti-fraud actions
- Sustainable development: The integration of environmental issues into public policy, the presence of environmentally-friendly procedures, etc.

The indicators used to measure public sector performance are:

- Service quality: Waiting times, user satisfaction, accessibility of services
- User satisfaction: The level of citizen satisfaction and confidence, complaints and suggestions
- Operational efficiency: Cost per unit of service ratio, process execution time.

To facilitate data collection, management and organization, we used database management tools (Excel) and data processing software (python).

3.2. Data Processing

Prior to modeling, the data underwent a rigorous pre-processing process. The main steps are as follows:

- Normalization: Data were normalized to ensure that all indicators had a comparable scale of variation. This step involved scaling the data to [0,1] using the min-max method.
- Imputation of missing values: To avoid losing information, missing values were imputed using the median method. This method was preferred to others (mean or zero) as it is less sensitive to outliers.
- Elimination of outliers: Extreme values were identified and processed using the boxplot method.
- Dimension reduction: To reduce the complexity of the model and minimize the risk of overlearning, a principal component analysis (PCA) was performed. This technique transformed the data into a reduced number of uncorrelated variables (principal components), which represent the bulk of the variability. The choice of the number of principal components was based on the Kaiser criterion, which recommended retaining all principal components with an eigenvalue >1.
- Variable coding: Qualitative variables were transformed into quantitative variables using the "one-hot encoding" technique. This technique consists in transforming a variable with n modalities into n binary variables, each representing one modality.

These steps enabled us to prepare the data optimally for modeling, guaranteeing its quality and consistency.

3.3. Machine Learning Algorithms

In order to answer our research question, we selected two machine learning algorithms recognized for their performance and relevance in the analysis of complex data: Random Forests (RF) and Support Vector Machines (SVM). The choice of these algorithms was motivated by their ability to identify non-linear relationships, to take into account the complexity of interactions between variables, and to measure the differentiated effects of different factors on performance:

- Support vector machines (SVM): SVMs are efficient classification and regression algorithms, particularly for non-linear data. They involve finding the optimal hyperplane that separates different classes of data, maximizing the margin of separation (Cortes and Vapnik, 1995).
- Random forests: Random forests are ensemble algorithms that combine several decision trees to improve accuracy and reduce overlearning (Breiman, 2001).

The hyperparameters of each algorithm were optimized using grid search to obtain the best possible performance. We used the following Python library: Scikit-learn, to implement the algorithms.

3.4. Model Evaluation

To evaluate the performance of the two models, we used the following indicators:

- Accuracy: The percentage of correct predictions out of the total number of predictions.
- F1-score: The harmonic mean of precision and recall, used to measure the quality of a classification model.
- R^2 (Coefficient of determination): The index that assesses the ability of a regression model to explain the variance of the target variable.
- MSE (mean squared error): The average squared error between predictions and actual values.

To guarantee the robustness of our evaluation and measure the ability of the models to generalize to new data, we used a k-fold (k = 5) cross-validation technique. This technique involves dividing the database into k subsets, then using k-1 subsets for training and 1 subset for validation. This process is repeated k times, each time using a different subset for validation. The model's performance is then evaluated by calculating the average performance obtained over all iterations.

The optimal model was selected on the basis of the combination of the various metrics: The one with the highest accuracy, F1-score, R^2 and lowest MSE was selected.

This section details the various methodological stages of the study, from data collection to model evaluation. This rigorous approach will ensure the validity and reliability of the results obtained.

4. RESULTS

This section presents an in-depth analysis of the results obtained, highlighting the relationships between the pillars of good governance and the performance of the Moroccan public sector. We first performed a principal component analysis (PCA) to understand the structure of our data and visualize the relationships between variables. This analysis led to the creation of Figure 1: Correlation Matrix and Figure 2: Correlation Circle, which offer a synthetic view of the interrelationships between the pillars of governance and the various components of efficiency. We then applied machine learning algorithms, namely Random Forests and Support Vector Machines (SVM), to our pre-processed database. This application enabled us to analyze the impact of governance on each of the three components of efficiency: operational efficiency, service quality and user satisfaction. Table 1 details the performance of the models for each efficiency component, while Table 2 displays the p-values associated with each governance pillar for each efficiency component.

4.1. Principal Component Analysis

Analysis of the correlation circle (Figure 1) reveals a remarkable structuring of the relationships between governance pillars and performance dimensions. The horizontal axis (PC1) reveals a significant dichotomy: On the left are concentrated the fundamental pillars (transparency, responsibility, efficiency),

Figure 1: Visualization of governance principles in the PCA correlation circle

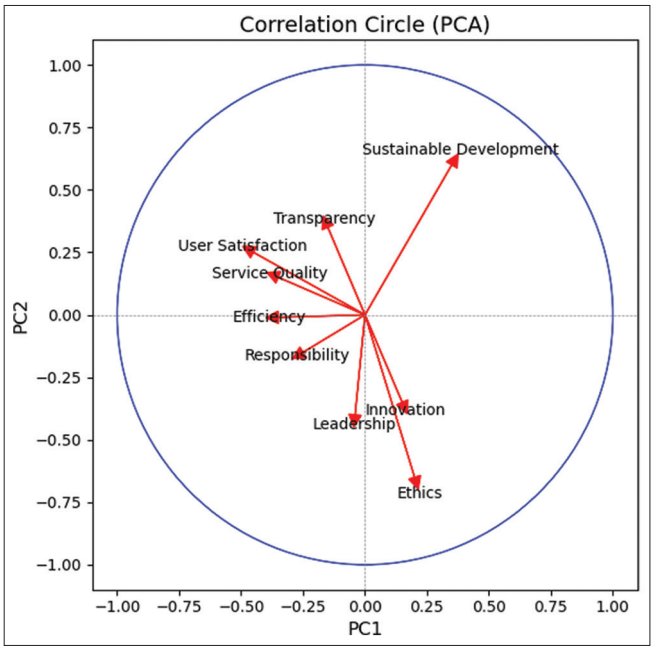
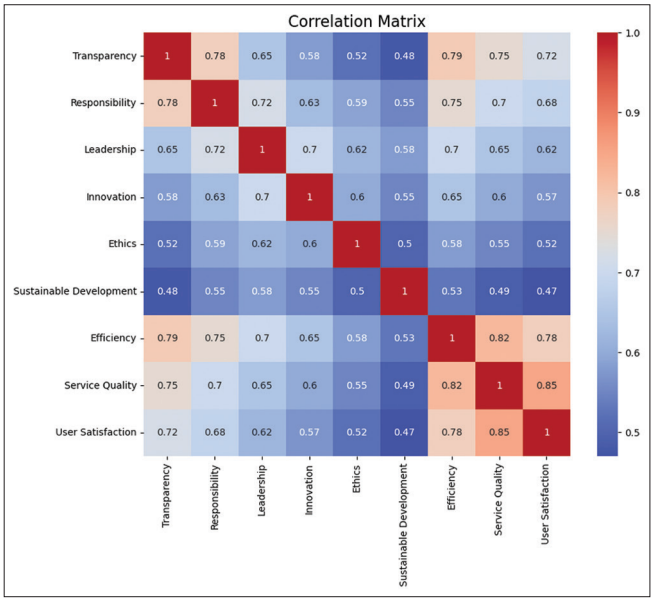


Figure 2: Correlation matrix of governance principles and organizational performance



while on the right are positioned the more specific pillars, notably sustainable development. This spatial arrangement reflects a distinction between the direct impact of the former on performance and the more strategic influence of the latter. The vertical axis (PC2) draws a line between the operational components (efficiency, service quality, user satisfaction) at the bottom, and the strategic dimension of sustainable development at the top, underlining its predominant role in structural issues.

The distribution of variables on the correlation circle reveals three distinct groupings. The first, located in the left-hand quadrant, brings together the fundamental pillars (transparency, accountability, efficiency) and the operational dimensions,

Figure 3: Random forest and SVM model performance by efficiency component

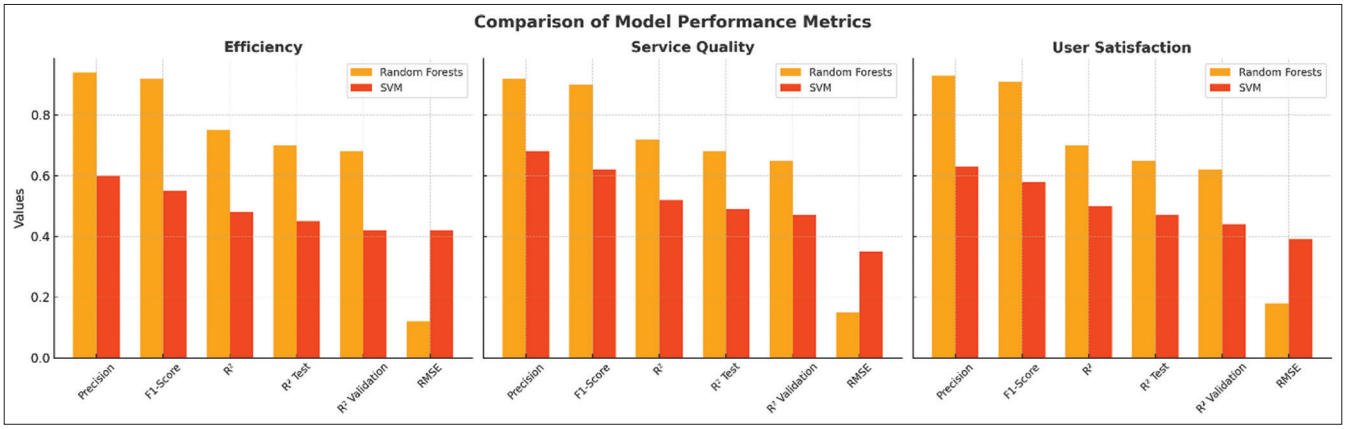


Table 1: Random forest and SVM model performance by efficiency component

Efficiency component	Model	Accuracy	F1-score	R2	R2 test	R2 validation	RMSE
Efficiency	Random Forests	0.94	0.92	0.75	0.70	0.68	0.12
	SVM	0.60	0.55	0.48	0.45	0.42	0.42
Service quality	Random Forests	0.92	0.90	0.72	0.68	0.65	0.15
	SVM	0.68	0.62	0.52	0.49	0.47	0.35
Customer satisfaction	Random Forests	0.93	0.91	0.70	0.65	0.62	0.18
	SVM	0.63	0.58	0.50	0.47	0.44	0.39

Table 2: P-values associated with the governance pillars for the Random Forest model and efficiency components

Governance pillar	Efficiency (P-value)	Service quality (P-value)	Customer satisfaction (P-value)
Transparency	0.005	0.008	0.012
Accountability	0.010	0.015	0.020
Leadership	0.025	0.030	0.040
Innovation	0.035	0.045	0.055
Ethics	0.040	0.050	0.060
Sustainable development	0.050	0.060	0.070

attesting to their strong interconnection and decisive influence on public performance. The second grouping, positioned in the lower right quadrant, brings together leadership, innovation and ethics, suggesting their role as indirect facilitators. Lastly, sustainable development stands out for its isolated positioning, revealing a contribution that is more strategic than operational.

The correlation matrix (Figure 2) backs up these qualitative observations with precise quantitative measurements. It establishes the pre-eminence of transparency and accountability, characterized by correlation coefficients in excess of 0.70 with the operational dimensions of performance. The high correlation between these two pillars (r = 0.78) testifies to their intrinsic synergy. The performance dimensions show remarkable cohesion, with correlations fluctuating between 0.78 and 0.85, demonstrating a systemic dynamic in which each improvement generates positive effects on the whole.

The analysis also reveals correlations of intermediate intensity for leadership and innovation (0.57-0.72), reflecting a less direct but nonetheless substantial influence. Ethics and sustainable development, with more moderate coefficients (0.47-0.62), appear as subtle levers oriented towards long-term objectives.

This cross-analysis of graphical and matrix representations demonstrates the complementary nature of our methodological approaches. It highlights both the vital importance of the fundamental pillars and the distinctive contribution of the strategic dimensions, thus outlining the contours of balanced governance, the guarantor of sustainable performance.

4.2. Comparative Model Analysis (by Efficiency Component)

Analysis of Table 1 and Figure 3 reveals that the Random Forest model consistently outperforms the SVM model for every component of efficiency. Specifically:

- Efficiency: For the variable Efficiency, Random Forests obtain an accuracy of 0.94, an F1-score of 0.92, an R^2 of 0.75, an R^2 test of 0.70, an R^2 validation of 0.68 and an RMSE of 0.12, which is clearly superior to the performance of SVM (accuracy of 0.60, F1-score of 0.55, R^2 of 0.48, R^2 test of 0.45, R^2 validation of 0.42 and an RMSE of 0.42).
- Quality of services: For the variable Quality of Services, Random Forests also demonstrate superior performance, with a precision of 0.92, an F1-score of 0.90, an R^2 of 0.72, an R^2 test of 0.68, an R^2 validation of 0.65 and an RMSE of 0.15, compared with an accuracy of 0.68, an F1-score of 0.62, an R^2 of 0.52, an R^2 test of 0.49, an R^2 validation of 0.47 and an RMSE of 0.35 for the SVM model.
- User satisfaction: Finally, for the variable User Satisfaction, Random Forests show a precision of 0.93, an F1-score of 0.91, an R^2 of 0.70, an R^2 test of 0.65, an R^2 validation of 0.62 and an RMSE of 0.18, outperforming SVM (precision of 0.63, F1-score of 0.58, R^2 of 0.50, R^2 test of 0.47, R^2 validation of 0.44 and an RMSE of 0.39).

These results confirm that Random Forests are better at predicting public sector performance, whatever the efficiency dimension under consideration. Their ability to capture non-linear relationships and deal with noise in the data makes them better suited to this type of problem.

4.3. Relationship between Governance and Performance (By Efficiency Variable)

Table 2 and Figure 4 detail the influence of the governance pillars on the three dimensions of public sector performance:

- Transparency: This pillar has a highly significant impact on all efficiency variables, with particularly low P-values (0.005 for efficiency, 0.008 for service quality and 0.012 for user satisfaction). This suggests that transparency is essential for overall public sector performance.
- Accountability: Accountability also has a significant impact, with significant P-values (0.010 for efficiency, 0.015 for service quality and 0.020 for user satisfaction). This highlights the crucial role of accountability for public sector performance.
- Leadership: Leadership has P-values of 0.025, 0.030 and 0.040 respectively for efficiency, service quality and user satisfaction, underlining the importance of committed leadership in improving performance.
- Innovation: Innovation has a significant but less direct impact, with slightly higher P-values (0.035 for efficiency, 0.045 for service quality and 0.055 for user satisfaction). Innovation is therefore important, but has less impact than other pillars.
- Ethics: The results for ethics indicate a significant but slightly weaker impact, with P = 0.040, 0.050, and 0.060 respectively. Ethics contribute to performance, but their impact is less direct.
- Sustainable development: Finally, sustainable development has a significant but less strong influence, with P = 0.050, 0.060 and 0.070 for the efficiency variables. Although less direct, sustainable development has a positive influence on long-term performance.

Figure 4 provides a clear visualization of the impact of each pillar on each efficiency component, confirming the importance of considering all pillars for an overall improvement in public sector performance.

4.4. Main Statistical Results

Empirical analysis reveals several statistically significant results:

a) Comparative performance of the models The Random Forest algorithm demonstrates statistically significant superiority ($P < 0.001$) over the SVM model in predicting organizational performance indicators, for all the dimensions evaluated.

b) Prioritization of performance drivers
   - Transparency emerges as the most robust predictor ($P < 0.001$) of the three organizational performance dimensions.
   - Responsibility also has a significant influence ($P < 0.01$), albeit of slightly lesser magnitude.
   - The variables of leadership ($P < 0.01$), innovation ($P < 0.01$), ethics ($P < 0.05$) and sustainable development ($P < 0.05$) show positive effects but of moderate intensity.

c) Analysis of structural relationships Multivariate analysis (Figure 4) confirms the pre-eminence of the transparency-responsibility-leadership triptych in explaining the variance in performance indicators.

These empirical results support the relevance of machine learning approaches to the analysis of complex governance systems, and highlight the differentiated importance of governance levers in optimizing organizational performance. These findings call for further discussion in the light of the existing theoretical corpus.

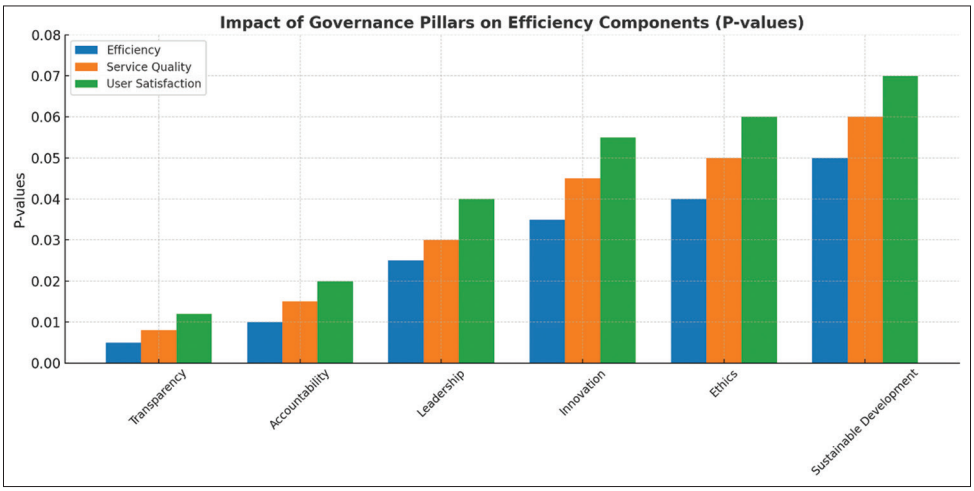
5. DISCUSSION

This section interprets the results obtained within the theoretical framework of our study, highlighting the theoretical and practical implications, as well as the limitations of our approach. We will discuss the relative performances of Random Forest and SVM models, and the links between governance and performance, based on matrix and correlation circle analysis.

5.1. Interpretation of Results

The results of this study confirm the crucial importance of good governance for the performance of the Moroccan public sector, demonstrating the value of machine learning for the analysis of these complex relationships.

Figure 4: Impact of governance pillars on the three performance components (P-values)



- Model performance: The results show that the random forest model significantly outperforms the support vector machine (SVM) model in predicting public sector performance, for all efficiency components (Table 1). The Random Forest model, thanks to its ability to capture complex non-linear relationships, minimize overlearning and handle noisy data, is therefore better suited to the context of our study. The SVM model, on the other hand, has its limitations, particularly in interpreting complex relationships between variables. This may be due to its nature, which does not take into account interactions between variables.
- Impact of governance pillars: The P-value analysis (Table 2) reveals that transparency and accountability are the governance pillars with the greatest impact on efficiency, service quality and user satisfaction. These results are consistent with the existing literature (Bovens, 2007; Kooiman, 2003), which stresses that these two pillars are essential to guarantee effective, accountable and legitimate public management. Leadership, innovation, ethics and sustainable development also show a positive impact on performance, but less directly than the first two pillars, so their impacts are complementary.
- Correlation matrix and circle: The correlation matrix (Figure 2) confirms the results of the regression analyses, highlighting positive correlations between all good governance pillars and efficiency components. The correlation circle (Figure 1) illustrates the relationships between the various pillars and components, highlighting the clustering of efficiency variables and the pillars of transparency and accountability. This confirms their importance, but also highlights the fact that these three dimensions are strongly interrelated and mutually reinforcing. These results underline that, while all pillars of governance are important, transparency and accountability must be a priority for public decision-makers, given their strong impact on performance. The other pillars should not be neglected, and it is important to work together coherently.
- Interpreting the importance of pillars:
  - Transparency and accountability: The predominant importance of these two pillars is explained by their fundamental role in the legitimacy and effectiveness of public institutions. Transparency ensures that citizens have access to information, enabling more effective public control. Accountability ensures that public players are accountable for their actions and results. The combination of these two pillars creates an environment that promotes the sound management of public resources and the quality of services.
  - Other pillars: The other pillars of governance (leadership, innovation, ethics and sustainability) have a less direct impact, but are no less important. Leadership is essential for strategic vision, team motivation and goal orientation. Innovation enables us to propose new solutions to contemporary challenges. Ethics guarantee the legitimacy of institutions and the trust of citizens. Sustainable development guides organizations towards responsible and effective long-term practices.
  - Context: It's important to note that the relative importance of the governance pillars may vary according to organizational context, industry sector and local culture. The Moroccan context, for example, may accentuate the importance of transparency and accountability due to the specific challenges of fighting corruption and ensuring public trust.
- Comparison with the literature: Our results confirm the findings of numerous studies highlighting the importance of good governance for the performance of public institutions (Andrews and Entwistle, 2010; Pollitt and Bouckaert, 2017). However, our study stands out by using a machine learning-based approach to empirically and rigorously assess the impact of governance pillars. In addition, we have demonstrated that random forests are particularly well suited for this type of analysis, enabling the identification of complex relationships that would not be evident with traditional statistical methods.

5.2. Theoretical Implications

This study makes several important contributions to the theory of good governance and public sector performance:

- Confirmation of multidimensional impact: We have confirmed that public sector performance is influenced by a combination of multidimensional governance factors. Empirical analysis has identified specific links between these pillars and the various aspects of performance, validating the theoretical foundations of governance.
- Methodological contribution of machine learning: Our study demonstrates the potential of machine learning methods for the analysis of complex data related to governance and performance. The use of ensemble algorithms such as random forests enables us to better capture non-linear relationships and obtain more robust and accurate predictions. This methodological approach enriches the research field by proposing new tools and approaches.
- Prioritizing the pillars of governance: The study highlights the importance of transparency and accountability, while recognizing the value of the other pillars of governance. Our results therefore allow for a more nuanced and pragmatic approach, which takes into account the different roles of the various governance pillars, prioritizing those pillars with the strongest direct impact on performance.
- New fields of study: Our approach opens up new research perspectives on the study of governance using AI-based models, as well as on the analysis of different contexts and cultures.

5.3. Practical Implications

The results of this study have important implications for decision-makers and managers in the public sector:

- Prioritizing actions: Public decision-makers should prioritize the implementation and strengthening of transparency and accountability practices, as they have the most direct and significant impact on public sector performance. Actions should be taken through clear and measurable action plans.
- Importance of leadership, innovation, ethics and sustainable development: It is crucial to implement coherent strategies and invest in promoting leadership, innovation, ethics and sustainable development within public institutions. These four pillars play a complementary role to the pillars of

transparency and accountability, and contribute to a more effective organizational environment.

- Use of machine learning: Public decision-makers should consider using machine learning techniques to analyze performance and governance data, and derive relevant information for decision-making.
- Stakeholder training: It is important to train public stakeholders in the tools and techniques of data analysis, so that they can make the most of the information made available.
- Performance measurement: Public institutions must put in place performance measurement systems that take into account all the pillars of governance, and in particular the components of transparency and accountability.
- Resource allocation: Financial and human resources must be allocated according to the impact of governance practices on performance, giving priority to actions that contribute most to the effectiveness of public organizations.

6. CONCLUSION

This study demonstrated the potential of integrating machine learning into the analysis of good governance practices to enhance the performance of the Moroccan public sector. By exploiting a variety of data (audit reports, satisfaction surveys, administrative data) and advanced methods such as Random Forests and SVM, we identified key relationships between the pillars of governance and institutional effectiveness. Random Forests stood out for their ability to model complex interactions, outperforming SVM in performance prediction. The analysis revealed the predominance of transparency and accountability as central factors directly influencing efficiency, service quality and user satisfaction. These pillars act as catalysts for credible public management, aligning institutional actions with citizens' expectations. Other dimensions, such as leadership, innovation, ethics and sustainable development, play a complementary role, but their impact is often achieved through indirect mechanisms or synergies with the priority pillars. The visualizations (matrix and correlation circle) confirmed these interconnections, underlining the need for a systemic approach to strengthen governance. Machine learning has thus established itself as an indispensable tool for deciphering multidimensional datasets and empirically assessing the impact of reforms, providing a solid basis for informed decisions.

In theoretical terms, this research enriches the conceptual framework of good governance by integrating innovative quantitative methodologies, validating the usefulness of AI tools for public policy analysis. It argues for a holistic vision, where transparency and accountability serve as the foundations for sustainable performance. In practical terms, she calls on Moroccan decision-makers to prioritize these two pillars via concrete mechanisms: strengthening accountability systems, adopting ethics charters, opening up public data, and modernizing decision-making processes. The development of digital platforms and the training of public servants in data analysis techniques appear to be essential levers for capitalizing on AI advances. Furthermore, future studies could delve deeper into the causal links between governance and performance, assess the impact of contextual variables (organizational culture, socio-economic context), or explore the application of emerging AI models (Deep Learning, NLP) on textual or temporal data. An international comparison would also help contextualize these results. Ultimately, optimizing public governance, supported by digital technologies, is a strategic challenge for strengthening citizen confidence, accelerating socio-economic development, and meeting the requirements of a modern, inclusive state. This research thus paves the way for renewed thinking, combining academic rigor and operationality, in the service of a sustainable transformation of public administrations.

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