

E-Maintenance and Industry 4.0: Empirical Insights and Statistical Validation of Performance Impacts

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Abstract. This article explores the empirical and statistical analysis of the impact of E-Maintenance and Industry 4.0 technologies on industrial performance. Based on data from 150 companies across France, Morocco, and Tunisia, the study investigates operational, financial, and qualitative outcomes of adopting advanced digital solutions. A mixed-methods approach combined semi-structured interviews and surveys with rigorous statistical tools, including reliability checks, Principal Component Analysis (PCA), and correlation assessments. Results show that 61% of surveyed firms adopted at least one Industry 4.0 tool. Strong and statistically significant correlations were observed between maintenance KPIs and quality performance ($r = 0.91$, $p < 0.01$), and moderate but significant correlations with financial KPIs ($r = 0.55$, $p < 0.01$). The PCA revealed four coherent clusters of technologies (data & automation, security & interconnectivity, human-machine interaction, and supervision), providing a structured lens for strategic prioritization. By combining field insights with statistical validation, this study delivers actionable evidence for managers and policymakers seeking to enhance competitiveness through digital transformation.

Keywords: Industry 4.0, Maintenance, E-Maintenance, Statistics, Empirical study, PCA, Correlation