Smart Digital Transformation: An Integrated Model for Measuring the Return on Investment of E-Management Applications in Enhancing the Competitiveness of Medium Sized Agricultural Projects in Iraq (2010-2024)

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Abstract

This study aimed to develop an integrated model for measuring the return on investment (ROI) of e-management applications in enhancing the competitiveness of medium-sized agricultural projects in Iraq (2010–2024). The study findings reveal significant annual growth in investment (23.4%) and technology adoption (16.8%), values that co-occurred with an average observed ROI of 185.3% and an NPV of 412.8 million USD. This association do not establish causality. Strong correlations (r = 0.934–0.994) between investment, technology adoption, and productivity are observed; however, these may reflect common time trends and do not confirm that e-management causes enhanced competitiveness. The study recommends increasing investments in e-management technologies, strengthening digital infrastructure, improving digital skills, promoting e-commerce, implementing supportive policies, and mitigating external risks to sustain the competitiveness of agricultural projects.

Keywords: E-Management Applications, Return on Investment (ROI), Competitiveness, Medium-Sized Agricultural Projects, Technology Adoption.

Introduction

From 2010-2024, the agricultural sector of Iraq (which is vital for the economy, exclusive of oil production) has encountered significant obstacles. Although its contribution to Iraq's GDP is approximately 5%, this sector suffers from many issues, including lack of up-to-date methods of operation and limited use of technology (along with poor

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management systems) [3]. One major part of the agricultural infrastructure consists of medium-size agricultural projects, and this segment is particularly challenged to compete with both regional and global markets due to current trends in climate change, water scarcity and the economic instability [12].

According to the Ministry of Agriculture's 2021 - 2025 Strategic Plan, policymakers have insufficient data and appropriate frameworks to develop quality policy and support mechanisms for digital transformation in the agricultural sector, and therefore require evidence-based methods for the development of digital agriculture [15] . There is great risk that medium-sized agriculture projects in Iraq will lack the competitiveness of regional neighbors as those countries ramp up efforts to digitalize agriculture [7]. The agriculture sector is extremely important for both food security as well as diversification of the economy in Iraq. Owners and managers of agriculture medium-sized projects are hesitant to invest in digital transformation projects because of uncertainty about the return on investment (ROI) [4]. As a result, the lack of reliable means to measure and predict ROI in medium-sized agricultural projects poses an unprecedented challenge for stakeholders regarding decision-making. The primary objective of this research study/hypothesis is to examine the relationship between digital transformation (in terms of the use of e-management applications) and the variables being studied. E-Management applications refer to digital tools and solutions that are utilized at the project level to increase the internal efficiency and effectiveness of resource and project management (i.e., such as, smart irrigation, GIS), as well as to gain access to market opportunities (i.e., e-commerce). These applications represent the operational component of the smart digital transformation of the medium-sized agricultural enterprises (MAEs), unlike that of centralized E-Government (which is an E-Government resource), and do not impact the return on investment (ROI) for these projects, nor do they provide any measure of the competitiveness of medium-sized agricultural projects. The observational design and aggregate data structure of the study precludes any ability to make causal inferences between the study variables.

The purpose of this research is to fill this gap by proposing a smart digital transformation model that provides the following: context-specific ROI metrics suitable for the realities of medium-sized agricultural projects in Iraq; evaluation frameworks for selecting suitable e-management applications; clear

pathways linking digital transformation investments with improved competitiveness; and longitudinal analysis tracking trends and changes from 2010 through to 2024. This will assist stakeholders in obtaining the tools and knowledge necessary for making informed investments in digital transformation within the agricultural sector of Iraq, thereby modernizing, enhancing resilience and increasing the competitiveness of this sector. The development of an integrated model linking the implementation of e-management applications with tangible competitiveness results through measurable ROI indicators is necessary to address this issue. The model must also be contextually appropriate for medium-sized agricultural projects operating under the unique circumstances found within Iraq from 2010-2024.

This study will investigate those issues related to Digital Transformation, E-Management, and Agricultural competiveness within the developing economy in Iraq. After promoting those policies through e-management of digitized CCP transformation, otherwise called Creative Commons Protocol, it tends to significantly improve medium-sized project outputs efficiency [(9) - (I) El Idrissi et al (10)]. Increased efficiencies have been seen, but Iraq has experienced severe shortages of skilled labour because of this [(21) – Wulandari et al. (21)], whereas, as noted by Pong et al (16), there are two things that we can take away from this. One is that electronic/digital platforms provide us with a competitive advantage; the second is that to lower your costs, you will generally need to have a well-functioning system in place when deciding to join a new business. Therefore, Ausat (8) has quantified the potential market access through e-commerce in comparison to the projected growth in E-commerce within Iraq of $86.2 million US within by 2025 [`13 - Farhan]. These findings add to the findings of a study done on e-management ROI (on establishing e-management infrastructures in Iraq) that also indicated the need to address infrastructure and human resources skills issue. Several academic journals are currently studying smart digitization and how it can benefit medium-sized farmers (medium) in Iraq. For example, Al-Aloosy [1] believed GIS can be used to create valid maps of Al-Suwaira soil fertility so that better decisions can be made about crop planning and management of resources, thereby facilitating digital transformation via improved decision-making (increasing digital transformation return of investment (ROI) by optimizing resource usage). Al-Wasity and Ahmed [6] examined the relative competitiveness of Iraqi date exportation using a range of

economic indices including, for example, revealed comparative advantage, thus demonstrating the feasibility of implementing electronic management systems (e-management) that would also lead to less excess in both supply chains and marketing efforts; in turn, improving ROI by average by large project (medium) approved for planting dates. Al-Wasity [5] identified that government subsidies had increased profit realized on corn production as well as reducing expenses resulting from using E-management technology. This also increases the potential to increase ROI on medium (medium) farms if electronic management was implemented instead of traditional methods. Sanaa and Salman (2002) projected the effect of the Iraqi dinar on the exchange rate for imported rice in 2028 and adaptive measures including e-management will improve financial planning and competitiveness. Additionally, the water footprint of wheat and rice imported from Iraq by Jeehan and Al-Badri (2000) provide the opportunity for environmentally sustainable usage of natural resources; therefore, e-management will increase knowledge of the sustainable management of water, with simultaneous improvements to ROI and sustainability of projects. Finally, Al-Badri (2001) stressed the profitability of beekeeping projects in Iraq which can be improved with successful costs control through e-management applications for ROI on your project and overall long-term viability of your project in medium to average-sized agricultural farms. To sum up, these studies have begun to show the potential for using digital technologies and economic interventions to adopt practices that create efficiencies, promote sustainability, provide competitive advantage and also continue to be desirable outcomes of smart digital transformation in the Iraqi agricultural sector.

The literature reveals some of the most crucial dimensions of this knowledge gap; it is being unknown what are the fits and effects for medium-size farming projects in Iraqi environment16.

The Long-Term Level Of Change The time frame of these actors in Iraq was an important time to be involved in humanitarian and development activities, but little or no academic research into how digital transformation interventions took place and their impact on agriculture development projects during this time is available....

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Materials and Methods

Through its quantitative approach to study design and methodology, this study was based within the context of the pragmatic paradigm and included elements of both long-term temporal trend analysis and statistical modeling for measuring the influence of adopting e-management applications on the competitive potential of medium-sized agricultural enterprises in Iraq from 2010-2024. Data used in the analysis were derived primarily from the following official government sources: Iraqi ministry of planning, ministry of agriculture, ministry of communications and other internationally related entities.

The study of "competitiveness" is approached by using three observable measures that are used together as a composite latent construct: (1) productivity efficiency (output per unit output as calculated using regression), (2) market integration (the volume of e-commerce transactions and production linkages), and (3) overall financial performance (return on investment, net present value, internal rate of return and payback period). The analysis tools of this study are organized hierarchically: descriptive trend analysis establishes points of entry (level 1), correlation-regression analysis assesses causal mechanisms (level 2), and economic principal component analysis evaluates feasibility and constraints (level 3). This tiered framework provides assurance that the "integrated version" will represent more than just an aggregation of strategies by providing a logically arranged analytical route connecting digital transformation investment to competitive results.

The analytical tools employed in this study are outlined as follows:

1- A 15 year longitudinal study of the strategic trends of the number of agricultural projects, total investment in e-management technologies, and technology adoption rates was used to determine growth patterns in these three areas. 2- Correlation between technology adoption and productivity/marketing measurements were determined using correlation coefficients and R2 scores to assess the relative strength of the association and amount of significance associated with the relationship.

3- Regression Model Limitations

Since official Iraqi statistics have limitations (e.g., no annual series on labor input and capital stock per sector) regarding the use of a univariate predictor, other factors must be taken into consideration because no marginal effect can be isolated from the simultaneous effects of technology adoption and other variables.

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4- Determining Return on Investment (ROI): Financial criteria are established to assess the economic viability of e-management investment such as: Return on Investment (ROI), Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period.

The Principal Component Analysis (PCA) is used as a challenge to create an outcome relationship between the challenges identified in attribute of being able to carry out the digital transformation. Factors such as technical infrastructure, human resources, economic constraints or social constraints were modeled to assess the variance in how much each of these factors impacted the success of an organization in terms of adopting e-management..

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Scope and Methodological Limitations :

The study employs an associational, not causal, design. The following limitations constrain causal inference:

Farm management capabilities or firm quality can be an underlying joint determinant of both technology adoption and productivity. Firms that operate profitably are likely to select themselves to digitally adopt (endogeneity). Some of the factors that are likely to affect both adoption and productivity are: government subsidies, soil fertility, water access, security situations, and global commodity prices, but there are no observations of these variables in aggregate data (omitted variable bias). Time series correlations may also be spurious due to trends or common influences of time periods (non-stationarity). Aggregation bias is present when collecting national-level data and concealing firm-level heterogeneity.

Consequently, all findings are interpreted as predictive associations within the observed 2010–2024 timeframe, not as proven causal mechanisms.

Results and discussion

All of the results highlighted within the Tables (1-7) provide overwhelming evidence for the success of Iraq's digital transformation in medium-sized agribusinesses between 2010 and 2024 with an integrated analytical framework that allows for ROI measurement and improved competitiveness.

Statistical analyses were made of the growth of e-management technologies that have occurred in order to support medium-sized agriculture in Iraq between 2010 and

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2024, and this research shows that through e-management technologies, there is an opportunity to enhance economic competitiveness (and thus grow the opportunity for companies or colloquially the economy as a whole), yet there are obstacles/circumstances that need to be overcome in order to sustain e-management technology growth. The longitudinal (Table 1) analysis (23.4 percent average annual growth) reveals that there has been continual growth of investment in both number of projects (3.1 percent on average year to year) and adoption of technologies (16.8 percent), all three measures exceed the numbers for agriculture that reflect worldwide digitalization of agricultural, notably increased investment in technologies such as mobile apps and e-commerce platforms, that provide an alternative means for generating efficiency and creating access to markets [11, 20] have also suffered from both political instability in Iraq (i.e. 2014) and the COVID-19 pandemic (i.e., 2020), making Iraq's agricultural sector susceptible to both internal and external shocks as also reflected in studies of economies affected by wars [18].

Correlational analyses (Table 2) show strong relationships between investment, adoption of technology, productivity and ecommerce (correlations range from 0.934 to 0.994) demonstrating the theoretical framework of digital transformation acting as a catalyst for increasing economic competitiveness. A nearly perfect correlation exists between the adoption of technology and productivity ($r = 0.994$, $R^2 = 0.988$), which illustrates the critical contribution of e-management tools to the efficient operation of agricultural processes. This is in line with their use in the majority of studies done on developing economies. The correlation of ecommerce to the adoption of technology ($r = 0.958$) demonstrates the growing significance of digital marketplaces which continues to be exhibited in the Global South. Taken together, these relationships indicate that Iraq's agriculture sector is successfully utilizing digital technologies to improve integration into the marketplace and thus, is positioned to obtain a competitive advantage.

The data presented in this research provides the empirical basis for concluding that technology adoption has a positive, moderate effect on productivity. The regression analysis (in Table 3) shows that there is a statistically significant positive relationship between technology adoption and productivity, with estimates indicating that for every 1% increase in technology adoption, productivity will increase by 0.61%. The regression model has a very high R-squared value of 0.978, indicating

that 97.8% of the variability in productivity can be explained by the variability in technology adoption. It is important to note, however, that the coefficient represents a measure of the correlation between the two variables; it cannot be interpreted as a causal relationship. The presence of endogeneity, omitted variables, and non-stationarity will prevent the interpretation of a causal relationship between technology adoption and productivity. Nevertheless, the very high predictive power of the regression model supports the use of quantitative models for agricultural planning and aligns with the precision agriculture research methodologies. The negative intercept (-2.15) observed in the regression model is a theoretical artefact, as no observations of technology adoption equal zero exist within the data set. Therefore, caution should be used when attempting to extrapolate the regression results beyond the observed range. Overall, the strength of the regression models supports the use of this research by policy makers in estimating productivity increases and in making informed resource allocation decisions.

The results of the study so far show that there has been a lot of work done on the different forms of digital transformation, but one of the common things discovered in researching this area has been the technical infrastructure or technology-based challenge facing many organisations looking at digital transformation. Through exploratory factor analysis, we have found that these are primarily weak service-quality internet connectivity and/or weak technical skills (42.3% of variance). This supports the research literature about the differences in developing countries where there are many discrepancies in terms of the lack of digital infrastructures and the lack of technical skills resulting in difficulty using technology. Economic barriers, including high implementation costs (28.7% of variance), also create additional issues around scalability, especially for medium-sized organisations with limited capital. These barriers indicate the need for specific interventions, such as public and private partnerships to improve infrastructure, and training programmes to enhance skills in using digital technologies; both of which have been proposed in similar contexts.

The results of the ROI analysis conducted in Table 5 demonstrate that e-management investments have a high degree of financial viability, averaging an ROI of 185.3% and producing a total NPV of 412.8 million dollars. Additionally, the average IRR of 67.4% combined with a very short payback period (2.1 years) exceeds the benchmarks for agricultural technology studies, illustrating that the

money invested in Iraq is generating an extremely efficient return on their investment relative to other countries. The financial success of the e-management investments validates the integrated model of this research for measuring ROI and provides a framework that can be modified and implemented in other developing economies that are pursuing digital transformation.

According to Table 6, continued growth is predicted for many sectors including e-commerce. E-commerce is predicted to grow at an annual rate of 45.2%, reaching an expected $86.2 million by 2025, based on a linear trend model. The continued growth in e-commerce will be driven by the rising rate of technology adoption and increasing internet penetration. Global projections for digital agriculture support this idea and suggest that Iraq could be well positioned for capturing this growing market for digital products. Though project number growth is very low (3.1%), this indicates a stronger emphasis on creating quality rather than quantity. This focus could create opportunities for continued projects to last longer and improve sustainability, however, all projects should be monitored carefully to ensure inclusivity throughout the sector.

Table 7 shows the findings and therefore provides an integrated analysis of sustained investment, infrastructure development, and predictive modelling as approaches that may help improve competitiveness while also overcoming obstacles. Although there are clear advantages from these findings and recommendation (derived from two different research methodologies), there are limitations due to reliance on aggregated data (with potential for obscured regional differences), and assuming linear relationships in one or more analysis (which may not fully represent the complexity of socio-economic issues). Future research could explore disaggregated data, which would help identify differences in sub-groups (i.e., governorates), as well as using non-linear analysis, in addition to assessing qualitative studies for improved understanding of social acceptance barriers that were identified from the factor analysis (i.e., resistance to change).

The findings of this research validate that the utilization of e-management technologies enhances the viability of medium-sized agricultural enterprises by increasing overall production, expanding market access, and improving financial returns. However, it is equally important to address both technical and economic limitations in order for these benefits to be sustained over time. The proposed integrated model creates a consistent mechanism to evaluate ROI and inform policy decisions; thus

contributing to a more robust global dialogue about the role of smart digital transformation within agriculture..

Temporal Trends and Economic Growth

The growth patterns of medium-sized agricultural businesses in Iraq between 2010 and 2024 are outlined in Table 1. The number of projects has increased at a lower rate over this time (average annual growth rate of 3.1%, with a coefficient of variation (CV) of 142.6%), but there is a noticeable separation in the rate of increase in e-management technology investments (average 23.4%, CV 48.3%) and technology adoption rates (average 16.8%, CV 31.7%). This evidence of divergent expansion aligns with Rogers' (2003) Diffusion of Innovation theory, which implies that resources move from innovator enterprises (those who have adopted the innovation before the early majority), but do not cross into the early majority until they have been accumulated sufficiently to allow for their deployment on a wide scale.

Ten Mann-Kendall trend tests indicate upward statistical trends in the amount of money being spent ($\tau = .87$, $p < .001$) and how efficiently companies utilize technology ($\tau = .82$, $p < .001$). The number of projects that have been completed shows no monotonic trend. There was a decrease in both the amount of money spent and number of projects completed in 2014 and 2020, coinciding with exogenous shocks (i.e., political instability in 2014 and COVID-19 in 2020), but evidence for rapid recovery supports the thesis of resilience in the conflict economy literature as discussed by Smith and Jones (2019).

Investment Growth Drivers There are three measurable drivers behind the growth of investment. 1. Policy Pull: A ministry of agriculture program that subsidized digital tools under the strategic plan for agriculture from 2021–2025 has reduced barriers to investing in the purchase of a digital tool for medium-sized agricultural projects. 2. Technology Push: The costs of hardware have decreased and internet penetration has increased at an annual rate of 21.3%, creating lower marginal costs when adopting e-management solutions. 3. Market Pressure: The digitalization taking place in neighboring agricultural sectors has created concern regarding the ability of Iraqi exports to compete based on price, which has encouraged investment ahead of the anticipated digitalization.

Iraq's medium-sized agricultural sector has developed through overcoming barriers through e-commerce development, developing skill and ability through the provision of better

infrastructure, and using good government support services to facilitate their activities by following Porter's Diamond model framework (1990)..

Table 1: *Correlation Longitudinal Analysis - Annual Growth Rates for Medium-sized Agricultural Enterprises (MAEs), and Investment Volume in E-Management Technologies in the Iraqi Agricultural Sector period (2010-2024). Analysis Between Key Variables.*

Year	Project Growth Rate (%)	Investment Growth Rate (%)	Technology Adoption Growth Rate (%)	Trend Analysis
2011	5.30%	40.60%	25.00%	High Growth
2012	5.40%	28.90%	20.00%	High Growth
2013	4.80%	25.90%	16.70%	Moderate Growth
2014	-2.10%	-6.80%	7.10%	Decline
2015	1.10%	20.60%	20.00%	Moderate Growth
2016	4.60%	28.00%	22.20%	Moderate Growth
2017	5.10%	31.40%	22.70%	High Growth
2018	5.80%	24.60%	14.80%	High Growth
2019	4.30%	25.00%	12.90%	Moderate Growth
2020	-1.20%	15.30%	8.60%	Decline
2021	4.10%	31.50%	18.40%	Moderate Growth
2022	4.50%	26.70%	13.30%	Moderate Growth
2023	3.80%	27.60%	13.70%	Moderate Growth
2024	3.40%	18.40%	8.60%	Moderate Growth
Average	3.10%	23.40%	16.80%	

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CV	142.60%	48.30%	31.70%
Mann-Kendall τ	0.34 (p=0.12)	0.87 (p<0.001)	0.82 (p<0.001)

Source: Calculated from Tables No:1 and 2 in appendix (Number of Projects and Investment Volume)**. Calculation Note,** Table 1 Calculation: As indicated, the growth rates were calculated using the standard annual percentage change formula: = ((Current Value - Previous Value) / Previous Value) × 100**.** The underlying time-series data (investment volume, project numbers) were derived from official Iraqi governmental sources over the 15-year period (2010–2024).

Causal Relationships Between Variables

Table 2 shows that the correlations (r = 0.934–0.994) are observed in longitudinal time-series data. However, this correlation may be inflated by common time trends(spurious correlation) and do not establish causality. The high statistical significance (p<0.001) confirms that these relationships are non-random, affirming the established theoretical framework of technology adoption driving productivity and investment acting as a primary driver for adoption.

Table 2: *Correlation Analysis Between Key Variables.*

R^2 Value	Statistical Significance	Relationship Strength	Correlation Coefficient (r)	Variable Pair
0.964	p<0.001	Very Strong Positive	0.982	Investment × Technology Adoption
0.988	p<0.001	Very Strong	0.994	Technology Adoption × Productivity

		Positive		
0.947	p<0.001	Very Strong Positive	0.973	Internet Penetration × Smartphone Adoption
0.918	p<0.001	Very Strong Positive	0.958	E-commerce × Technology Adoption
0.872	p<0.001	Strong Positive	0.934	Project Numbers × Investment

* Competitiveness is operationalized as a composite construct integrating productivity, e-commerce volume, and financial returns . It is not included as a standalone variable in this correlation matrix.

* the correlations reflect co-movement of variables over time. They do not establish that investment "leads to" adoption or that adoption "causes" productivity. First-differenced correlations are substantially lower (r = 0.58–0.71), suggesting that level correlations are inflated by common time trends.

Source: Calculated from 1, 2, 4, and 5 in appendix (All Key Indicators)

Pearson Correlation Coefficient: $r = \Sigma [(xi - \bar{x}) (yi - \bar{y})] / \sqrt{[\Sigma (xi - \bar{x})^2 \Sigma(yi - \bar{y})^2]}$on

Predictive Modeling

Table 3 shows a linear regression model to predict productivity increases based on the rate of technology adoption, expressed as: Productivity Increase = -2.15 + 0.61 × (Technology Adoption Rate). The slope coefficient (β = 0.61) indicates that a 1% increase in technology adoption is associated with a 0.61% observed rise in productivity, within the 2010-2024 timeframe this assortation does not imply causation due to potential endogeneity and omitted variable bias. high statistical significance ($p < 0.001$). Although the negative intercept (α = -2.15) suggests negative productivity in the absence of technology adoption, this is practically irrelevant as adoption rates were never zero. The model's high goodness-of-fit ($R^2 = 0.978$, Adjusted $R^2 = 0.976$) ; however, this value is likely inflated by common time trends and the absences of competing predictors(labor, capital, climate) in the univariate specification. He F-statistic (595.36, $p<0.001$) reflects the large sample-to-predictor ratio (n=15, k=1), not robust explanatory power. A first-

differenced multivariate specification(including labor and capital proxies)would be required for credible structural interpretation. This associational model offers a reliable tool for forecasting within historical bounds, not for causal policy evaluation, reinforcing the research objective of quantifying the impact of e-management technologies on agricultural competitiveness through enhanced productivity.

Table3: *Regression Analysis - Productivity Prediction Model.*

95% Confidence Interval	p-value	t-statistic	Standard Error	Coefficient	Parameter
[-4.02, 0.28]	-0.032	-2.42	0.89	-2.15	Intercept (α)
[0.56, 0.66]	<0.001	24.4	0.025	0.61	Slope (β)

*The very high R^2 (0.978) reflects common time trends between technology adoption and productivity rather than true explanatory power. With only one predictor, R^2 value cannot be compared to multivariate specifications. First-differenced regression yields R^2 = 0.42, suggesting that time-trend components dominate the level regression.

Source: Calculated from 1 and 4 in appendix (Technology Adoption and Productivity).

Model: Productivity Increase = $\alpha + \beta \times$ (Technology Adoption Rate) + ε

Prediction Equation: Productivity Increase = -2.15 + 0.61 × (Technology Adoption Rate)
Model Fit: R^2 = 0.978, Adjusted R^2 = 0.976
F-statistic: 595.36 ($p<0.001$)
Interpretation: For every 1% increase in technology adoption, productivity increases by 0.61%.

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Identification of Barriers

Table 4 identifies 4 factors grouping barriers to embrace e-management technologies in Iraq's medium-sized agricultural projects (MSAPs), after conducting a principal-component analysis (PCA). The 4 factors explain 100% of the variance. The technical infrastructure factor, which represents 42.3% of the variance, includes weak internet infrastructure and lack of technical skills, is identified as the highest priority to adopt e-management technologies (0.85-0.91 factor loadings). The economic barriers factor represents 28.7% of the variance; includes low government support and high costs to implement; could be identified as medium/high priority. The social acceptance factor represents 19.1% of the variance; includes resistance towards change and privacy concerns. The local environment factor represents 9.9% of the variance; includes a lack of localised solutions to MSAPs. According to the adequacy of the model; the KMO=0.78 and Bartlett's test (χ^2=89.3, $p<0.001$) confirm this. The results of this research will provide policymakers guidance for prioritising needs for infrastructure improvement and skills development, which coincides with the research goal of establishing and addressing barriers to enhancing competitiveness of agricultural projects (MSAPs) through digital transformation..

Table 4: *Return on Investment (ROI) Analysis.*

Payback Period (Years)	ROI (%)	Net Present Value	Estimated Returns (Million USD)	Profit Increase (%)	Investment (Million USD)	Year
2.1	1124.0 %	36.0	39.2	2%	3.2	2010
	1148.0 %	66.6	72.4	4%	5.8	2012
	1184.0 %	80.5	87.3	7%	6.8	2014

	1232.0 %	129.4	139.9	11%	10.5	2016
	1292.0 %	222.2	239.4	16%	17.2	2018
	1352.0 %	335.3	360.1	21%	24.8	2020
	1412.0 %	583.2	624.5	26%	41.3	2022
	1460.0 %	911.0	973.4	30%	62.4	2024

Source: Calculated from Tables 2 and 4 in appendix (Investment and Profit Increases)

ROI = ((Attributes Net Returns – Total Cos of Ownership/ Total of Ownership) × 100**.**

Attributes Returns estimated by controlling for non-digital factor(weather, subsidies, commodity prices**)**
NPV = Σ (Cash Flow / (1 + r) ^t) - Initial Investment Average ROI: 185.3%
Average Payback Period: 2.1 years
Total NPV (2010-2024): $412.8 million
Internal Rate of Return (IRR): 67.4%
Investment Assessment: Highly Profitable and Efficient.

Financial Feasibility

According to Table 5, the investment in e-management technology with an average 185.3% return on investment (ROI) (1124% in 10 years from now, (1460% in 15 years from now) is financially viable for Iraq's Medium Sized Agriculture (MSA) projects. ROI was calculated as RO = [(Net Returns - Investment) ÷ Investment] × 100, suggesting profit margins have increased by 2% to 30% while estimated profits are likely to peak at 973.4 million in the year 2024. Therefore, the total NPV of the 412.8 million $(in year 2024) and IRR of 67.4% indicates that e-management technology can yield a significant return on investment. These findings are supporting the goal of researching how ROI can influence the decision to invest more in order to continue

developing and expanding digital transformation efforts within agricultural MSA projects over time..

Table 5: *Revised ROI Calculations (Conservative Scenario).*

Year	TCO (Million USD)	Net Incremental Profit (Million USD)	Revised ROI (%)	Payback (Years)
2010	5.5	1.8	**32.70%**	3.1
2012	9.8	3.6	**36.70%**	2.7
2014	11.5	4.2	**36.50%**	2.7
2016	17.8	7.8	**43.80%**	2.3
2018	29.2	14.1	**48.30%**	2.1
2020	42.2	22.4	**53.10%**	1.9
2022	70.2	42.6	**60.70%**	1.7
2024	106.1	71.8	**67.70%**	1.5
AVERAGE			**47.40%**	**2.3**

Source: Calculated from Tables 1, 2, 3, 5, 6 in appendix (Time Series Data).

Future Growth Forecasting

Table 6 illustrates the long-term growth of significant components contributing to the digital transformation within agriculture in Iraq using trend lines produced from linear equations that have a high r^2 value (between 0.952 & 0.994), along with forecasts of future values for 2025 according to each trend as follows: online purchasing has the greatest year-over-year growth at 45.2% and is projected to amount to $86,200,000, thereby providing an indication of immense growth resulting from advances in technology. The anticipated investment amount will increase by 23.4% and reach approximately $68,700,000; while internet usage/availability will grow by 21.3%, reaching an estimated percentage of 71.2%, indicating a strong underlying growth in digital infrastructures and advancements. Additionally, adoption rates for new technologies will increase by 16.8%, reaching 67.6%, while both future project quantity and total number of new projects will increase by only 3.1% for a total projected quantity of 4,058. These growth forecasts clearly indicate the sustainability of digital

transformation and that online purchase volume and adoption rates for new technologies are two of the main contributors to increased competitiveness. In conclusion, this analysis aims to provide information for forecasting longer-term growth and is supportive of future strategic planning to improve competitiveness in Iraq's Agriculture Sector..

Table 6: *Statistical Summary and Research Recommendations.*

Practical Recommendation	Confidence Level	Statistical Significance	Key Finding	Analysis Type
Continue current investment strategy	95%	$p<0.05$	Consistent growth across all indicators	Longitudinal Analysis
Develop integrated predictive models	99.9%	$p<0.001$	Strong positive relationships between variables	Correlation Analysis
Use model for strategic planning	99.9%	$p<0.001$	High predictive accuracy (R^2 = 0.978)	Regression Analysis
Prioritize infrastructure development	95%	KMO = 0.78	Technical challenges are primary barriers	Factor Analysis
Increase investment allocation	90%	IRR = 67.4%	Exceptional returns (185.3% average)	ROI Analysis

Analytical Integration and Strategic Recommendations

The digital transformation of Iraq's medium-sized agricultural projects is summarized in Table 7 by combining statistics with strategic recommendations for improving the competitiveness of these projects. The longitudinal analysis confirms that

growth has been steady over the period studied (p-value < 0.05), while the correlation analysis indicates that the different variables are highly correlated with each other (p-value < 0.001) and could thus be used to create combined predictive modelling. Additionally, regression results show that the predictive accuracy (R^2 = 0.978) of the model can help strategic planners develop more robust plans. Based on the results of factor analysis, technical challenges were the most significant hindrances to progress (Kaiser-Meyer-Olkin [KMO] = 0.78), and additional infrastructure investment is needed. Through the analysis of return on investment (ROI) for the median ROI of the medium-sized entities in the study (average ROI = 185.3%, internal rate of return [IRR] = 67.4%), we encourage additional investment. The results of the combined analyses meet the needs of the researchers, as they provide an overall model to measure ROI and will provide donors and policymakers with the information necessary to increase agricultural competitiveness through continued digital transformation..

Table 7: *Main Challenges Facing E-Management Implementation in Medium-Sized Agricultural Projects (Percentage Reporting the Challenge).*

2024*	2022	2020	2018	2016	2014	Challenge
35%	43%	52%	65%	78%	85%	Weak Internet Infrastructure
40%	48%	57%	68%	75%	82%	Lack of Technical Skills
42%	50%	58%	65%	72%	76%	High Implementation Costs
35%	42%	50%	58%	65%	70%	Resistance to Change
35%	42%	50%	57%	64%	68%	Lack of Government Support

*Data for 2024 represents preliminary estimates for the first half of the year

Data Source: - Ministry of Agriculture - Agricultural Sector Challenges Survey for years (2014, 2016, 2018, 2020, 2022) and First Half Estimates 2024, {24}.

- Central Statistical Organization - Technical Challenges Survey (2014, 2016, 2018, 2020, 2022).

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Conclusions and Recommendation

"E-management technology adoption has been demonstrated through correlation to increase productivity; iventure capital has expanded utilization; iventure capital has produced higher financial return on investment over the four years of data collection. In particular, the longitudinal analysis demonstrates persistent increases (23.4% total) in investments made to e-management technologies in medium-sized agricultural projects since the study began. Additionally, the analysis of e-management technology adoption shows an acceleration of adoption rates (from 16.8% to 21.4%) over the same period of time. This acceleration is expected but subject to exogenous disruptions (e.g., significant disruptions as evidenced in 2014 and 2020)."

The regression model has an R^2 value of 0.978 which indicates a significant predictive relationship between the two variables - technology adoption and productivity over time; however, no causal conclusions can be made from the analysis because the data was collected using an observational design and the data was aggregated. Also, while "competitiveness" is measured as a composite construct (i.e., productivity + market access + financial viability) it is not measured separately as a latent variable.

According to conservative standards of risk-adjusted financial feasibility analysis, the average Return on Investment (ROI) is 47.4% (Range: 14.6% Pessimistic - 68.2% Optimistic) with a Payback Period of 1.5 years to 3.1 years. Projects will continue to be economically viable as long as they have adequate infrastructure support, skills development and mitigated risks. Limitations -There is potential for Aggregation Bias; the National Data Obscures the Disparities between the Governorates with Respect to Infrastructure, Security and Agricultural Specialization -Due to the Endogeneity Risk; there are no studies Being Conducted to Address the Reverse Causality (i.e. Profitable Projects Self-Select into the Adoption of Digital)

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Validity Beyond Kurdish Region of Iraq : Findings based on medium-sized projects in the institutional context of Iraq ; each finding must be reproduced in another medium size project. Quality Of Data : Use of governmental statistics may result in potential measurement errors especially in relation to the informal economy. Future Recommendations Implement Develop Implementation Matrix For 2025-2030 Risk Management Plan 1. Political : Establish a contingency fund (priority i) to facilitate phased implementation with defined reversing milestones.

Economic Risk: Use currency hedging on technology purchased from overseas; develop a local supplier base to lessen the amount of foreign currency exposure. Technical Risk: Use of open-source software to reduce vendor dependency; create back-up connectivity through fiber and satellite-based systems. Social Risk: Develop community champion programs to assist with overcoming opposition to innovation; create data privacy policies to build trust in the sponsor of new technology. Future Research Directions: Carry out a rigorous evaluation using causal designs such as difference-in-differences and instrumental variables based on variation in government policies at the governorate level.

Collecting Microdata: Collecting Microdata using Firm-Level Panal Surveys for replacement to Aggregate Statistics. Non-Linear Modeling; Using Machine Learning Methods to Model Interaction Effects and Threshold Effects. Comparative Replication: Expansion into Agriculture-Based or Agricultural Economies Affected by Conflict. Used to Test External Validity.

Dynamic ROI modeling: Real options valuation to account for flexibility value under uncertainty.

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Table 8: Prioritized Implementation Matrix for Digital Transformation in Iraqi Medium-Sized

Priority	Recommendation	Timeframe	Estimated Cost (Million USD)	Expected ROI (Baseline)	Risk Level	Implementation Mechanism	Responsible Actor
1	**Rural broadband infrastructure**	Short-term (1–2 years)	45	N/A (enabling)	High (political/ security)	Public-private partnership; Ministry of Communications + Telecom operators	Ministry of Communications
2	**Farmer digital literacy programs**	Short-term (1–2 years)	12.5	35–50% (productivity gains)	Medium (adoption resistance)	Vocational training centers; mobile training units	Ministry of Agriculture + NGOs
3	**Subsidized e-management tool adoption**	Medium-term (2–4 years)	28	40–60% (ROI model)	Medium (fiscal sustainability)	Matching grants (50% government, 50% farmer); tax incentives	Ministry of Agriculture + Finance
4	**Localized solution development**	Medium-term (2–4 years)	18	25–40% (usability premium)	Low–Medium (technical)	Innovation hubs; university–industry partnerships	Universities + Private sector

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5	**E-commerce platform integration**	Long-term (3–5 years)	22	55–70% (market access)	Medium (market volatility)	National agricultural e-marketplace; export certification digitalization	Ministry of Trade + Agriculture
6	**Contingency fund for external shocks**	Continuous	15.0 (annual reserve)	N/A (insurance)	High (unpredictable)	Sovereign risk insurance; sectoral stabilization fund	Ministry of Finance + Central Bank

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Author Contribution

Muna Abdul Qader Ahmad conceptualized the study, designed the research model, collected and analyzed the data, and interpreted the results. The author solely prepared, wrote, and revised the manuscript, ensuring the accuracy and integrity of the data and findings presented. All sections—including introduction, methods, results, and discussion—were developed and finalized by the author.

Conflict of Interest

The author declares that there are no conflicts of interest regarding the

publication of this article. No financial, institutional, or personal relationships influenced the design, execution, or interpretation of the study.

Novelty Statement

This paper outlines a newly developed integrated model, which is used to quantify the return on investment (ROI) of e-management applications for medium sized agricultural projects in Iraq's one of a kind socio-economic environment. Previous studies have used only longitudinal trend analysis (2010 – 2024) or economic indicators (ROI, NPV, and IRR), or digital competitiveness. This integrated model will allow for a complete assessment of the financial and technological impacts of digital transformation in agriculture, by combining all three methods together. This model will also measure profitability and determine the causal relationships between the adoption of technology, productivity, and competitiveness. It will provide policymakers and/or other stakeholders with a replicable method for making evidence-based decisions about digital investments..

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