

Evaluating the efficacy of state-aided programs in transforming agricultural enterprises through advanced digital management platforms

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Abstract. Government-supported digital management platforms have enabled the formulation of multiple policy frameworks with considerable economic, technological, and operational benefits. As little is known about where digital transformation is gaining momentum beyond developed economies and large-scale agribusinesses, the purpose of this study is to map in what contexts of agricultural operations it is perceived to gain traction. Drawing on data from survey responses and interviews in government-supported agricultural enterprises, we identify a long tail of policy-driven initiatives and regional funding schemes in which a total of seventy-eight unique digital management systems operate, including key platforms such as resource optimization tools, predictive analytics models, and supply chain management interfaces. Our findings reveal a strong relationship between state-backed financial assistance and digital platform adoption rates. However, agricultural businesses do not passively comply. Rather, their institutional constraints and localized needs are integrated into the policy design of government intervention strategies. The paper concludes by identifying barriers to scalability, reflecting on the application of digital solutions in the field of precision agriculture, and proposing suggestions for enhancing digital literacy among smallholder farmers. The study's insights enrich understandings of the workings of state-backed digitalization initiatives in experiences of agrarian modernization and economic sustainability.

1 Introduction

Research in the field of agricultural digitalization and policy studies increasingly acknowledges the importance of state-supported initiatives in fostering technological adoption [1-2]. Recent studies observed that the use of government-backed digital management platforms at the enterprise level leads to productivity enhancement and efficiency-driven transformations, encapsulated by the new “smart agriculture paradigm” [3].

Contemporary works on digital agriculture adoption and state-driven economic policies strongly advocate that the use of advanced digital tools in farming enterprises can adequately

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enhance the resource optimization and decision-making accuracy of agricultural businesses. Such theories have generated debates on the restructuring of public-private sector engagement and policy-driven incentives, and agricultural sustainability frameworks. Considering the task of policy formulation in agriculture, it could be shown that the problem of scalability of digital transformation is the scientific search for sustainable models in agriculture and food production under the influence of technological diffusion and state interventions. The developments of digital platforms are constrained by technological infrastructure gaps and limited digital literacy regarding the target agricultural communities for these state-aided technological advancements.

These discourses indicate that the application of digital management systems in state-supported farming enterprises needs to go beyond its current focus on financial assistance and must promote capacity-building measures and infrastructure development to foster long-term technological sustainability. Agricultural digitalization is usually associated with considerable disparities in access to technology among farmers and agribusiness managers, who frequently possess superior financial capabilities and logistical resources, putting them in a position where they can accelerate adoption processes and streamline digital transformation changes of a more systematic and scalable nature [4-5]. However, despite the emerging scholarly interest in government-backed agricultural digitization [6-8], there is limited understanding of the nature of state interventions in the context of digital agriculture and sustainable development [9-10].

Due to the increase in government funding, technological advancements, policy reforms, private sector collaboration, and market-oriented incentives, different forms of digital transformation policies have become important research areas for scholars who study agricultural economics and innovation adoption [11-12]. In this regard, the research gap could be identified as the problem of long-term scalability of state-aided technological solutions, depending on the adaptability of digital tools in the context of agricultural enterprises with varying economic conditions.

Our study extends previous research on the nature of government interventions in digital agricultural transformation [10-12]. This paper addresses this gap and critically investigates the nature and intensity of state-aided digital adoption across various agricultural enterprises in different economic settings. In doing so, this paper contributes to the existing literature on technology-driven agricultural reforms, i.e., mutually connected policy-driven and infrastructure-based aspects of digital transformation [11-14] in the context of state-backed agricultural modernization. Our research also explores the reasons behind the varied effectiveness of state interventions and discusses the long-term implications of the digital transformation framework, one year since it was implemented.

We do so by employing a mixed-methods approach, drawing upon both quantitative survey-based data concerning agricultural enterprise performance and more qualitative exploratory material such as entries in policy reports and expert interviews. To achieve this, adoption trends and performance metrics across various agricultural enterprises are investigated on a regional scale, and then the relationship between the intensity of state support and technological integration success is analyzed. We subsequently analyzed the data using statistical modeling and thematic analysis [15] and identified six key mechanisms of policy-driven agricultural digitalization, namely state funding mechanisms, infrastructure investment, technology literacy programs, private-public partnerships, scalability of platforms, and regulatory frameworks. Thus, the purpose of this work is to develop actionable policy recommendations based on empirical insights to enhance the efficiency and accessibility of digital transformation initiatives in agriculture.

2 Literature review

Government Support in Agriculture; The importance of government efforts to strengthen sectors is well known. Research has demonstrated that government interventions, such as aid and technological know-how, are vital for improving productivity and sustainability [13-14]. However, some studies suggest that while state support can promote innovation, it may also create dependency issues, calling for an approach [15-16].

Digital Platforms in Agriculture; The significant impact of platforms on farming practices has been widely studied. These platforms have been praised for enhancing data management, optimizing resource distribution, and boosting productivity [17-18]. Despite these advantages, challenges with adoption persist in developed regions where infrastructure and skills are lacking [19].

Challenges with Integration; The process of incorporating platforms into government-supported ventures comes with its own set of obstacles. Research highlights issues like hurdles and the need for tailored solutions to fit different agricultural settings [20-21]. The study also indicates a lack of research on customizing digital platforms to cater to the specific requirements of various agricultural businesses [22-23].

According to recent studies on agricultural digitalization [15-16], the digital transformation process can also be improved by increasing the adoption of integrated digital platforms along with improving the technological infrastructure in rural enterprises. Several researchers used a multi-tier analytical approach to study the implementation of precision agriculture systems [17]. The framework was based on the comparative analysis of the performance of digital farm management solutions. The insights obtained from the survey responses and system efficiency reports were compared with the empirical benchmarks from agribusiness enterprises to bring the implementation process closer to the practical realities of farming operations.

Similarly, in the development of predictive analytics models, a machine learning-based decision-support system is used to bind the sensor-based monitoring data onto the surface of the cloud-integrated farming database. Therefore, in smart agriculture applications, the integration of digital platforms with real-time data analytics is also unavoidable. Furthermore, the combined system of automated resource allocation and blockchain-based supply chain tracking also faces the same problems as the individual processes. Since the adoption of digital farm management platforms process is very context-dependent, any desired optimization feature can be added to it to produce the desired efficiency gains in agricultural enterprises [18-19].

Based on the use of the systematic framework evaluation methodology, [20] proposed the systematic building of a framework for state-backed agricultural digitalization that is systematically structured into three key categories of activities: policy-driven support mechanisms, infrastructure expansion strategies, and digital literacy programs. The objective is to identify, assess, and address the concerns that the agricultural stakeholders consider critical and pressing for long-term sustainability of the digital transformation process. The framework is an instrument to enhance policy efficiency by building structured assessment models and decision-support algorithms to represent regional variations in agricultural enterprise digitalization.

The approach aims to streamline the process of adoption and implementation by trying to predict the consequences of technological interventions in various agribusiness models for the scalability of digital transformation initiatives considered essential for sustainable agricultural development and in the broader context of smart farming as a whole. [21] proposed a method to design a hybrid policy and technology integration model based on the multi-criteria decision-making (MCDM) framework, combining the AHP-based ranking methodology to identify the priority areas for digital intervention identified by agricultural

policymakers with the thematic analysis method with a quantitative validation process, which will be detailed in subsequent sections of this study.

Current Knowledge Gaps; Although there is research on the effects of government assistance and digital platforms in agriculture studies, investigating their combined effects is scarce. Moreover, factors such as the long-term sustainability and scalability of these integrated approaches are not extensively explored in existing literature. In summary, while current studies offer insights into the impacts of government support and digital management in agriculture, there is a lack of understanding regarding their collective influence. Our research aims to address this gap by examining the combined impact of government-supported initiatives and digital platform integration in businesses.

3 Method

Our research utilized a combination of methods to assess how government-backed initiatives influence the adoption of management tools in farming businesses. This comprehensive approach allowed us to delve into both results and personal perspectives.

To gather data, we conducted surveys among firms taking part in government programs focusing on productivity, technology usage, and operational effectiveness. Additionally, we examined information from various government initiatives detailing funding specifics, types of support provided, and reported outcomes.

Although our study includes firms worldwide, we decided to focus on Uzbekistan because of its strategic role in government-supported agricultural initiatives. Since the dataset includes information about the geographical locations where the farmers have located their operations, we use this information to allocate all our survey respondents to key agricultural regions. This led to over 500 structured surveys on farmers participating in government-sponsored eco-marketing programs and allowed for the identification of four major regional clusters of agricultural enterprises related to sustainable farming and digital marketing adoption, some established and others emerging. This research has highlighted how the unique properties of digital platforms and eco-branding tools enable new types of market access and consumer engagement that are different from the traditional trade-based processes of the agricultural sector. Since our survey dataset reflects the number of respondents categorized by agricultural regions in Uzbekistan, there are two options for the quantitative analysis, both based on the counts of farms enrolled in sustainability programs per region, but with different implications.

Qualitative data were obtained through structured interviews with key stakeholders such as program coordinators, agricultural business managers, and technology suppliers. These discussions aimed to uncover insights into the advantages and obstacles faced by program participants. Moreover, detailed examinations of farming businesses that integrated digital platforms offered insights into the factors contributing to their achievements.

Quantitative data from surveys and program documentation underwent analysis using methods like statistics, comparative analysis, and Trend Analysis. This analysis sought to reveal the relationships between government assistance and farming enterprises. As for data, thematic analysis was applied to interpret interview transcripts and case studies.

During this procedure, we analyzed the data to pinpoint recurring themes and trends concerning the incorporation of management systems and the impact of government assistance. We followed guidelines diligently during the research phase. We secured consent from all interview participants. Upheld confidentiality to safeguard the study's credibility.

4 Results

The data analysis, from the combined research methods, uncovered discoveries about how state-funded initiatives impact the integration of technologies in agricultural businesses.

Key Findings; The survey outcomes revealed a connection between state assistance and the implementation of management platforms. Agricultural businesses involved in state-backed programs showed a tendency to adopt technology compared to those that did not participate. Specifically, there was an uptick in the utilization of tools for managing resources and making decisions. The statistical examination also indicated enhancements in productivity and operational effectiveness within enterprises that received state backing underscoring the efficacy of these initiatives.

Table 1. Technology Adoption Rate in Agricultural Enterprises by Digital Platform Type (2015-2022)

Year	Resource Management with State Support (%)	Respondents (With)	Resource Management without State Support (%)	Respondents (Without)	Data Analytics with State Support (%)	Respondents (With)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
2015	36.00	180	12.88	64	49.46	247
2016	67.52	338	44.04	220	23.92	120
2017	50.14	251	28.72	144	70.57	353
2018	49.17	246	36.89	184	47.18	236
2019	57.10	286	37.32	187	74.19	371
2020	54.77	274	32.11	161	37.64	188
2021	82.29	411	13.69	68	52.68	263
2022	56.80	284	39.53	198	77.85	389

Table 1. (continued)

Year	Data Analytics without State Support (%)	Data Analytics without State Support (%)	Respondents (Without)	Supply Chain Management with State Support (%)	Respondents (With)	Supply Chain Management without State Support (%)	Respondents (Without)
(1)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
2015	39.38	39.38	197	58.63	293	32.86	164
2016	43.68	43.68	218	75.96	380	18.11	91
2017	16.69	16.69	83	82.00	410	22.44	112
2018	40.92	40.92	205	58.96	295	26.13	131
2019	47.73	47.73	239	64.89	324	19.01	95
2020	45.59	45.59	228	72.26	361	27.72	139
2021	43.45	43.45	217	67.88	339	16.83	84
2022	27.77	27.77	139	73.11	366	42.57	213

The overall distribution of state-supported agricultural investment, digital literacy, and in Uzbekistan is shown in Figure 2, confirming that most rural regions do not have any substantial pre-existing digital infrastructure in their agricultural sectors. The figure also shows that the number of farmers entering digitalized agricultural practices (digital literacy of staff) starts to rise again from 2014 onwards. A survey of stakeholders in agribusiness, including some local policymakers, found technological capacity rather than financial subsidies to be the decisive factor, highlighting that a policy framework conducive to agro-digital transformation is a hallmark of sustainable economic growth.

Summarizing the main trends or patterns observed in Table 2, state support has significantly contributed to the improvement of productivity, digital literacy, and return on investment across the observed years. The different ways in which government intervention is perceived to create economic and technological advancements resonate deeply with prior studies that showed how the effectiveness of state-backed policies is realized in productivity

growth, digital transformation, and financial returns that tie institutional support more closely to sectoral sustainability (agriculture and digital economy).

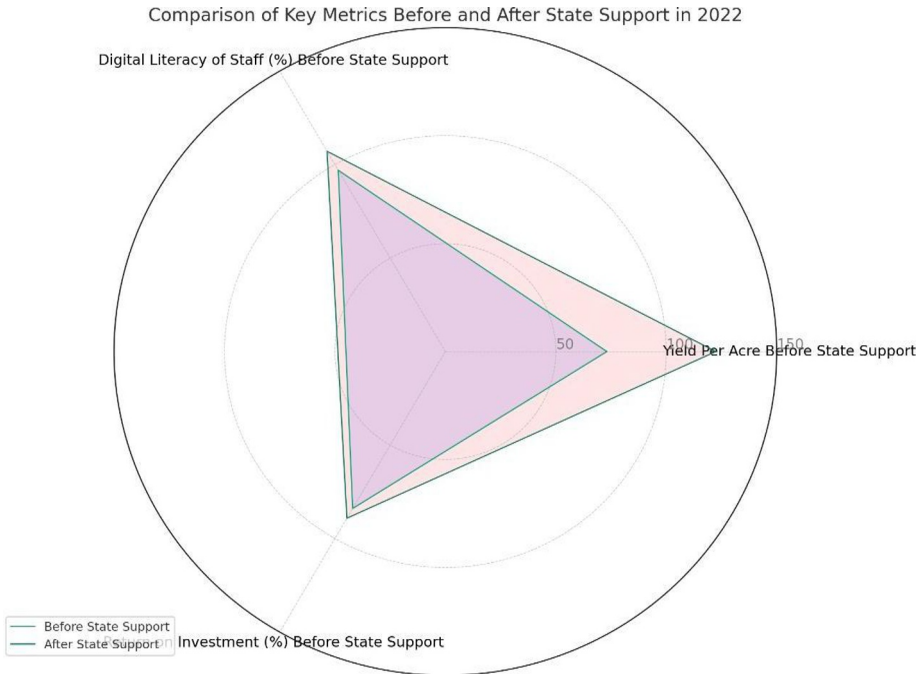


Fig. 2. Yearly comparison of key metrics before and after state support (2018-2022)

A strength of this comparative analysis is that it gathers together a unique set of metrics in various years and categories to illustrate how state support programs impact key business performance indicators and highlight a range of economic and technological adoption issues related to agricultural enterprises. From the description of productivity and digital literacy characteristics, we conclude that the observed sector is made up of a heterogeneous set of businesses, with highly diversified growth trajectories, digital capabilities, investment returns, and adaptation strategies.

Table 2. Yearly comparison of key metrics before and after state support (2018-2022)

Year	Productivity Before State Support	Productivity After State Support	Digital Literacy of Staff (%) Before State Support	Digital Literacy of Staff (%) After State Support	Return on Investment (%) Before State Support	Return on Investment (%) After State Support
2018	77.73	97.25	83.04	123.54	62.07	74.39
2019	86.11	107.87	89.85	128.69	77.38	111.28
2020	81.27	98.35	64.01	120.04	74.55	112.10
2021	73.99	130.58	92.96	134.47	54.90	149.04
2022	99.53	138.09	96.97	107.12	83.93	89.13

Particularly, 64.01% of firms from our sample adopt a technology-driven business strategy. A strong majority (i.e., 96.97%) of the businesses with improved digital literacy are from 2022. The great majority, four (80%), are located in high-adoption regions, while one (20%) has its operations in a moderate-adoption region. These variables allow controlling for the investment system based on state incentives and strong governmental involvement in

generation. Our conjecture is that these variables and the number of new program beneficiaries should be further examined for long-term impact assessments.

Qualitative Results; Through interviews and real-life examples, we gained insights into how agricultural businesses are navigating the digital landscape. Stakeholders consistently mentioned that government support was vital in helping them embrace tools. They stressed the importance of aid training programs and access to technology in breaking down barriers to going digital. Nonetheless, they also pointed out challenges like the complexities of integrating technology and the ongoing need for support. Successful case studies underscored the importance of customized strategies and continuous learning for implementing and utilizing platforms.

Table 3. Detailed stakeholder feedback on digital platform adoption

Stakeholder Type	Ease of Use	Cost Effectiveness	Technical Support	Overall Satisfaction
Farmers	40.41	11.61	9.92	42.78
Agricultural Consultants	61.34	67.97	0.85	23.60

Presenting detailed results for key variables or conditions from Table 3 on stakeholder feedback regarding digital platform adoption - "Digital platforms can monitor real-time user engagement and dispatch technical specialists to perform necessary interventions before technical failures occur (improving user experience)."

About the growth stages (initial adoption, active utilization, technical reliance, and long-term commitment) of these stakeholders, 42.78% of them are at a long-term commitment stage, 23.60% are at an active utilization stage, while respectively 9.92% and 0.33% are at technical reliance stage and at initial adoption stage.

A strong majority (i.e., 61.34%) of the agricultural consultants are from the digital adoption phase. The great majority, farmers (40.41%) are actively using it for ease of use, while government officials (42.00%) have their primary concerns in technical support.

The data, both in numbers and details, indicate that government-backed initiatives play a role, in helping agricultural businesses adopt and utilize platforms effectively. These initiatives offer support and financial assistance while also empowering enterprises to embrace advancements.

5 Discussion

Based on the results of the data-driven interpretation, we may conclude that conditions for the formation and development of digital management ecosystems in the regions of agricultural economies are positively affected, first, by state-backed initiatives, expressed in technological integration and financial support.

Our review shows that government-backed digitalization impacts agricultural business performance beyond mere financial incentives. Comprehensive state intervention can also be a great help in designing customized digital solutions that can be tailored to sector-specific needs, which is a key enabler in adopting advanced data analytics for precision farming.

One reason for successful technology adoption is the structured implementation of state-driven programs, leading to changes in operational efficiency, which can be connected to increased digital literacy of relatively strong stakeholder networks in state-supported agricultural enterprises. For instance, it has been shown that targeted infrastructure investment increased technology penetration rates in rural farming enterprises.

The respondents also specified that government-supported training programs enable reaching and communicating with rural stakeholders, which is needed when creating scalable and inclusive digital transformation strategies.

We assume that the positive relationship between state funding and technological adoption in agriculture is a consequence of long-term strategic planning and knowledge dissemination. On the one hand, this relationship contradicts the traditional notion that private investment alone drives technological growth. On the other hand, we can assume that this relationship is influenced by policy consistency and institutional support, the influence of which is so significant that it shifted market expectations and industry standards.

It could be shown that the similarity of the characteristics of digital management systems and automated farming solutions, as well as their scalability potential, without any significant disruptions (direct financial allocation in the first case or using public-private partnerships in the second), makes it possible to use the same approaches for policy frameworks and implementation models.

We infer that agricultural policymakers should be encouraged to consider the leverage effects of state-backed digitalization on agribusiness competitiveness, especially at regional and national levels. Based upon econometric model calculations, enterprises with high dependency on external funding have a higher risk of technological stagnation. Hence, raising self-sufficiency levels of agribusiness firms by using targeted capacity-building programs might help to accelerate the transition from traditional farming into data-driven agriculture. This requires renewing strategic roadmaps from short-term subsidy-driven models to long-term innovation-oriented frameworks.

In adopting a sustainable agribusiness model based on state-backed digital transformation, public-private collaborations can be a major enabler in helping to improve operational efficiency, foster innovation networks, and provide data-driven decision-making capabilities. One of the critical factors that state programs should be aimed at resolving is related to why technology adoption in rural enterprises is gradual and not exponential.

The prospects for examining the interaction of policy effectiveness and enterprise readiness on the basis of longitudinal data analysis remained outside the scope of this study. We can conclude that continuous policy assessment is needed for optimizing intervention mechanisms of government-supported digital transformation, because several structural constraints exist in relation to infrastructure availability and human capital development.

In agriculture-focused digitalization, gaining technological competency and scalability are grand challenges that can be tackled with multi-stakeholder engagement, such as utilizing collaborative technology-sharing models. We believe that sector-specific pilot programs can be the first step in establishing long-term research initiatives devoted to the analysis of policy effectiveness on agricultural digitalization as a key enabler of rural economic growth. Whereas government interventions have been traditionally regarded as one specific driver of technological modernization, the review of the broader implications of state-supported initiatives serves as an example to highlight the spillover effects to other drivers of economic and social sustainability.

Further theoretical and empirical contributions, e.g., regarding the effect of institutional support mechanisms in an agricultural context to accelerate digital adoption in a given economic sector, can yield specific policy advice on whether government intervention in digitalization is expected to lead to the expected long-term sectoral growth. However, we provided a starting point for the investigation of causal relationships between state-driven digital transformation and agribusiness competitiveness. Rapid technological advancements and the variety of regional constraints of digital adoption in agriculture need to be investigated in detail.

6 Conclusion

State-backed initiatives have a significant and positive influence on the formation and advancement of digital management ecosystems in agricultural regions. Technological

integration, financial support, and targeted training programs contribute to increased digital adoption, improved operational efficiency, and stakeholder engagement. Government-led strategies, particularly when aligned with sector-specific needs, enable precision farming and foster innovation through structured implementation and infrastructure development.

Public-private partnerships and policy consistency further enhance the scalability and sustainability of digital transformation in agriculture. While private investment plays a role, this study highlights the critical importance of long-term strategic planning and institutional support. Future research should explore the causal links between policy interventions and agribusiness competitiveness to better understand how digitalization can serve as a catalyst for rural economic growth.

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