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Commercialization of Technologies in the Indian Agriculture Sector: A study on Farmers Acceptance level

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Abstract

This research examines how farmers in the Indian agricultural sector embrace the new technologies. The study dives into the factors that influence adoption, assesses the consequences on livelihoods and productivity, and makes recommendations for decreasing barriers to incorporating technology into farming practices. There is very little research available in this field. When comparing Scopus data, only twelve publications are technology-related, and one file aims to explore TAM in a nation like India with vast majority engaging the farming sector. To assess small- and medium-sized peasants' intentions to embrace agricultural technology, the current study uses 750 sample data points. This study employs indigenous factors to explore fundamental TAM and exogenous variables inspired by the 4A's of marketing to evaluate their impact on technology adoption. The third stage of the research study additionally looked at the moderating effects of education, landholding size, and area of residence on the link between TAM and actual usage that would result in commercialization of Technologies in Indian agriculture at bottom line. The researcher utilized SPSS-25 and PLS-SEM to analyze the data.

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and Commercialization.

Introduction

India's agriculture industry is the backbone of the nation's economy, supporting around 60% of the population and making a sizable GDP contribution.[1] The industry confronts several obstacles in spite of its critical function, such as low productivity, dispersed landholdings, poor infrastructure, and restricted access to contemporary technologies.[2] In order to overcome these obstacles and increase agricultural profitability and productivity, agricultural technology commercialization has grown in significance. The process of commercializing agricultural technology entails the creation, sharing, and acceptance of innovations that can boost yields, improve farming techniques, and raise the value chain's overall efficiency.[3] From high-yielding seed varieties and precision farming instruments to digital tools for market access and climate-smart agricultural practices, these technologies cover a broad spectrum of developments.[4]

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However, as farmers are the technologies' final consumers, their acceptance and adoption will determine how well these technologies are commercialized.[5] Developing successful tactics to encourage the adoption of new technologies requires an understanding of farmers' acceptance levels and the variables influencing their adoption decisions.[6] Adam Smith's notion of absolute advantage is primarily realized through digital and technology breakthroughs across sectors in the production of goods and services.[7] "Right to win" and defeat the competition is the slogan of every sector. Nonetheless, global research on digitalization has shown that, despite its obvious benefits for sectorial growth, it has resulted in a growing digital divide between and within economies, as well as between different sectors, societies, communities, and demographic groups.[8] The same behavior may still be observed today. India's demographics and cultures are marked by tremendous variety and inequality.[9]

Agriculture is one of the sectors in India that has a wide range of stakeholders, particularly agricultural communities.[10] According to the studies, a methodical and step-by-step strategy to efficiently implementing digital technologies, particularly in distant places, is required.[11] The majority of Indian farmers reside in rural regions and lack access to infrastructure and other technical developments available in other industries.[12, 13]

Indian Consumer Profile and Agriculture Sector

The consumer profile of the Indian market is quite diversified and diverse, including a wide spectrum of market categories.[14] Studies show that the digital revolution is characterized by the development of digital technology, the widespread use of smart phones, and the expansion of internet access. These improvements need to be used gradually and with workable solutions in order to overcome the execution problems that lead to the digital divide.[15] Thus, every aspect of society will gain equally from the digital revolution.

Despite its poor productivity, agriculture remains India's most significant industry, providing for the great majority of people.[16] Further research reveals that there is a socioeconomic divide among the rural agricultural community's inhabitants.[17] Although the people depend heavily on this sector, they make up a smaller portion of the economy. The benefits of digital technologies are not available to those in the agriculture industry as they are to those in other industries.[18]

The objective of this research is to investigate the commercialization of technology in the Indian agriculture sector, with a particular emphasis on the analysis of several aspects that impact farmers' acceptance levels and intentions. This study aims to provide light on the obstacles and enablers of technology adoption by investigating the variables that affect farmers' decisions to adopt new technologies. Policymakers, academics, and agribusinesses will be able to better adapt their methods and interventions to increase the adoption of good technologies with the support of these results, which will eventually result in increased agricultural production and sustainability.

Purpose of the Study

According to the research, agricultural technology application revolves upon the beliefs and perspectives of the farming community.[19] Additionally, it is stated that there is a dearth of research on the perspectives of agricultural peasants by social scientists and economists, which is thought to have a major impact on how quickly innovations are adopted.[20] According to Dessart,[21] there exist other variables that are linked to the comprehension of peasants and impact their outlook on the use of technology in decision-making. In order to better encourage and execute the use of technologies in the sector of agriculture, it is advised to expand and start a methodical comprehension and inquiry to evaluate the peasants' views.

Conceptual Framework and Theoretical Background

The current conceptual framework draws influence from the 4A's marketing framework and extends the Technology Acceptance Model (TAM).[22] The primary motivation behind this model is to comprehend not only how consumers perceive digital adoption based on the Technology Acceptance Model (TAM), but also how availability and other infrastructure factors affect human views. Exogenous variables under investigation were other physical variables that have a significant impact on the perception of the individuals under study, as perceptions are only conceptual and abstract in nature. This allowed the study to test the intentional behavior of the individuals in the Technology Acceptance Model.

As a result, additional variables and parts of the physical infrastructure of digital technologies are included in the latter portion of the model. The degree of competence and the applicability of the technology are used to confirm their impact on the adoption process of technology in the agriculture industry.

According to Schacter and Daniel,[23] perceptions are at the abstract and conceptual level and refer to how a person perceives sensory data. The study centers on the accessibility of the current digital infrastructure. In other words, factors like perceived ease of use (PEU) and perceived usefulness (PU) of the technologies, as well as their impact on a sensory process that in turn reflects on perceptual levels and influences people's attitudes (ATT) toward embracing new technologies in their day-to-day work lives, are all related to accessibility (ACCE), compatibility (COMPT), trial ability (TRA), and Internet usage efficacy (IUE). To put it another way, perception serves as a lens through which to observe reality; it is not a reality in and of itself. Perception influences decision-making and motivates action based on reality.[24]

Accordingly, the study views the TAM components for perceived ease of use (PEU), perceived usefulness (PU), and actual behavior as endogenous variables within the model. To confirm their influence on TAM constructs, the model further incorporates the area of peasants' dwellings (RU-Rural & Urban), educational attainment (EDU) levels, and size of landholding (SLH) as moderating factors.

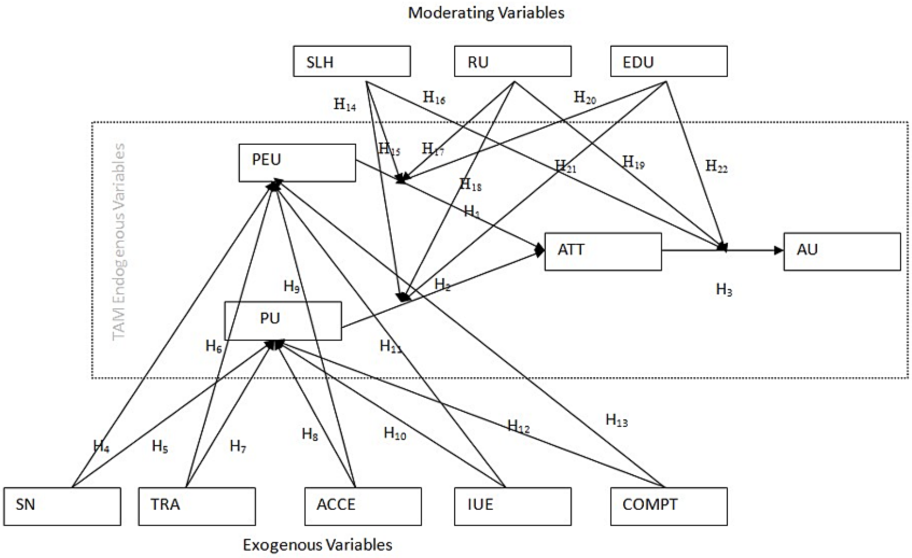

Fig.1: Conceptual TAM model developed for the study

The research shows that integrating and using technologies in agriculture can lead to higher production and farmers' income.[25] While farmer well-being receives a lot of attention, technology adoption may be greater, particularly in emerging and poor nations.[26] It is clear that the supply and demand sides of any technology are crucial to its success in spreading and being adopted in agriculture.[27] Knowledge of the people, technology availability, awareness, and risk implications are demand side elements that impact.[28] Infrastructure accessibility, regulatory support, investment in agricultural technologies and research, and institutional setups that enable technology transfer are examples of supply-side variables.[29] In any sector, a perfect balance between the supply and demand of technologies is necessary to accelerate progress and achieve desired results.[30]

According to Swaminathan,[31] the public sector in India bears a great deal of responsibility as it has been the primary driver of agricultural research up to this point. As new technical advancements in the agriculture sector emerged, the private sector also started doing research and development.[32]

In reality, a lot of research has been done to lower risk and increase proficiency by focusing on demand side variables.[33] The distribution of the enhanced technologies is greatly impacted by each of these variables. It would be better to concentrate more on the perspectives of small and marginal peasants. Because perception serves as a lens through which reality is perceived. The research incorporates TAM models and integrates marketing mix elements, influencing perceptual levels deemed noteworthy.[34]

Objectives of the Study

The present study focuses on examining the three broad categories that are

1. To investigate the impact of endogenous variables that lead to the real use of technology in the agricultural sector.
2. To investigate how exogenous variables affect endogenous factors when it comes to agriculture's adaptation of technology.
3. To examine how much the moderating factors—education, area of residence, and land size—have a beneficial impact on TAM.

Hypotheses

Based on the objectives mentioned above, the hypothesis is framed under a broad classification and is categorised factor-wise.

- **H_1, H_2, and H_3:** Endogenous variables positively influence the perceptions of the individuals resulting in Technology adoption.
- **H_4, H_5, H_6, H_7, H_8, H_9, H_{10}, H_{11}, H_{12}, H_{13}, and H_{14}:** Exogenous variables positively impact PU and PEU.
- **H_{15}, H_{16}, $H1_7$, H_{18}, H_{19}, H_{20}, H_{21}, and H_{22}:** Moderating variables positively influence Actual Digital Usage in Agriculture.

Table 1: Demographic Profile of the Respondents in the study.

Demographic Profile of the Respondents					
		Frequency	Per cent	Valid Percent	Cumulative Percent
Gender	Male	599	80	80	80
	Female	151	20	20	100
	Total	750	100	100	
Education	Illiterate	244	33	33	33
	Primary	149	20	20	53
	Secondary	140	19	19	72
	Intermediate	99	13	13	85
	Degree	86	11	11	96
	PG & above	32	4	4	100
	Total	750	100	100	
Marital Status	Married	672	90	90	90
	Unmarried	78	10	10	100
	Total	750	100	100	
Annual Income (in ₹)	≤ 50,000	176	23	23	23
	50,000-100000	317	42	42	65
	100000-1,50,000	183	24	24	90
	≥ 150,000	74	10	10	100
	Total	750	100	100	
Size of Land Holding	Less than 5 acres	508	68	68	68
	5 to 10 Acres	196	26	26	94

	More than 10 Acres	46	6	6	100
	Total	750	100	100	
Area of Residence	Rural	675	90	90	90
	Urban	75	10	10	100
	Total	750	100	100	

Methods and Materials

The study's major goal is to assess Peasants' attitudes on technology adoption. The basic concept is to evaluate the Technology Acceptance concept (TAM) by applying Perceived Usefulness (PU), Perceived Ease of Use (PEU), and Attitude (ATT), resulting in Actual Usage (AU) of the technologies, with a primary focus on endogenous variables under the Model. Furthermore, the Model continues to incorporate exogenous aspects obtained from the A's of Marketing and their influence on the Model. The later section of the research also includes moderating variables such as place of residence, educational level, and amount of land holding, which aid in any increase in technology acceptability. In this aspect, the study used deductive reasoning to reach the conclusion. A questionnaire approach was used to collect replies from the respondents.

Data Collection Procedure and Analysis

The study's target respondents are peasants. Hence, the stratified sampling technique is appropriate. Initially, a questionnaire is distributed using quota sampling by selecting erstwhile districts of Telangana, followed by data collection from farmers with due procedure. A total of 811 questionnaires were gathered from peasants in southern India, with the great majority coming from Telangana State, and missing data was analyzed using SPSS-25 software. The Structural Equation Model was fitted using PLS software in this investigation. During this procedure, almost 61 questions are removed to match the Model. As a result, the final research received 750 answers and was verified.

The table above shows the demographic data for the research sample. Among the main groups are those based on gender, education, amount of land holdings, income ranges, marital status, and place of residence. A total of 831 peasants answered the survey questions. Nevertheless, 750 are omitted in order to accommodate the data for thermal analysis into the Structural Equation Model (SEM). As a result, any outliers and any deviations with the largest distance from the base value are eliminated from the research using the Mahalanobis distance approach.[35]

Validation of Model Fit for PLS-SEM

The following table shows the model fit metrics, with values of 0.006, 0.867, and 1256.479 for SRMR, NFI, and Chi-square value, respectively. Less than 0.08 to less than 0.10 in PLS-SEM are the ranges where the Standardized Root Mean Square Residual (SRMR) criteria indicated satisfactory fit falls.[36] The Bentler Fit Index, also known as the Bentler and Bonett Index, ranges in value from 0 to 1. Lohmöller[37] asserts that a number that is more closely aligned with 1 and heading toward 0.9 indicates a better match. As a result, the study finds that the present criteria improve model fit. The Variance Inflation Factor (VIF) (Annexure) was tested in order to ascertain the degree of multicollinearity. The VIF values fall within the allowed range of fewer than five, which means that the model does not exhibit a critical degree of collinearity.[38]

Table 2: PLS-SEM Model fit summary

Model Fit summary		
	Saturated Model	Estimated Model
SRMR	0.043	0.066
d_ULS	0.588	1.433
d_G	0.271	0.328
Chi-square	1050.081	1256.479
NFI	0.889	0.867

Discriminant Validity

It is clear from Heseler[39]'s Heterotrait-Monotrait ratio (HTMT) table that discriminant validity between the two reflective constructs in the study has been proven for values below 0.90. This clearly shows that the structures under study are unrelated to one another.

Table3: Showing the Discriminant Validity of Model with Heterotrait-monotrait ratio (HTMT) matrix values

Discriminant validity Heterotrait-monotrait ratio (HTMT) - Matrix									
	ACCE	**ATT**	**AUG**	**COMPT**	**IUE**	**PEU**	**PU**	**SN**	**TRA**
ACCE									
ATT	0.649								
AUG	0.386	0.278							
COMPT	0.790	0.808	0.284						
IUE	0.563	0.613	0.383	0.556					
PEU	0.563	0.627	0.512	0.677	0.715				
PU	0.664	0.801	0.204	0.843	0.481	0.589			
SN	0.301	0.418	0.067	0.452	0.362	0.283	0.483		
TRA	0.422	0.480	0.193	0.528	0.408	0.437	0.493	0.414	

Construct Reliability

The statistics show that every value in Cronbach's alpha-related constructs is 0.70 or higher, with the exception of Accessibility, which has a respectable value of 0.698. The composite reliability levels are closer to 1, indicating an excellent model fit. Two of the constructs had values lower than the suggested values of 0.479 and 0.489, despite the fact that the average variance derived should be larger than 0.5. According to the study, when the composite reliability is larger than 0.6, values of 0.4 and above are acceptable, suggesting that the constructs' convergent validity is acceptable.[40]

Table 4: Showing the construct Reliability and Validity of the model

Construct reliability and validity Overview				
	Cronbach's alpha	**Composite reliability (rho_a)**	**Composite reliability (rho_c)**	**Average variance extracted (AVE)**
ACCE	0.698	0.719	0.701	0.479
ATT	0.824	0.836	0.828	0.618
COMPT	0.754	0.774	0.754	0.489
IUE	0.915	0.915	0.914	0.780
PEU	0.824	0.824	0.824	0.701
PU	0.843	0.843	0.843	0.573
SN	0.844	0.847	0.845	0.732

Results of Structural Model for Endogenous and Exogenous variables under the Study

After assessing the model fit for the PLS-SEM in this investigation, the path coefficients were analyzed at the second level of analysis to confirm the hypothesis. The major purpose of the first portion of the PLS-SEM study is to test the hypothesis about indigenous characteristics such as perceived utility (PU) and perceived ease of use (PEU) on individuals' attitudes (ATT) that lead to actual technology usage (AUG). This is Davis's genuine TAM model, which focuses entirely on the peasants' perceptive abilities and intentions to absorb technology. The second level of the first component examines external elements that promote and encourage individuals' technology adoption. At this level, the study considered the constructs inspired by the 4A's Model of Marketing, such as Social Norms (SN), Trailability

(TRA), Accessibility (ACC), Internet Usage Efficacy (IUE), and Compatibility (COMP), as extraneous variables in the model. The table below shows the results of the Structural Model judgments for the initial segment of the investigation.

Table 5: Hypothesis testing of Endogenous and exogenous variables in TAM

Path coefficients Mean, STDEV, T values, p values							
Hypot -hesis		**Original sample (O)**	**Sample mean (M)**	**Standard deviation (STDEV)**	**T statistics (|O/STDEV|)**	**P values**	**Decision Supported/ Not Supported**
H_1	PEU -> ATT	0.245	0.245	0.048	5.101	0.000	Supported
H_2	PU -> ATT	0.652	0.653	0.047	13.853	0.000	Supported
H_3	ATT -> AUG	-0.135	-0.135	0.017	7.876	0.000	Supported
H_4	SN -> PEU	-0.118	-0.120	0.042	2.829	0.005	Supported
H_5	SN -> PU	0.133	0.131	0.041	3.283	0.001	Supported
H_6	TRA -> PEU	0.063	0.062	0.040	1.568	0.117	Not Supported
H_7	TRA -> PU	0.053	0.051	0.038	1.394	0.163	Not Supported
H_8	ACCE -> PU	0.021	0.014	0.104	0.203	0.839	Not Supported
H_9	ACCE -> PEU	-0.121	-0.127	0.100	1.205	0.228	Not Supported
H^{10}	IUE -> PU	-0.015	-0.018	0.044	0.342	0.732	Not Supported
H_{11}	IUE -> PEU	0.513	0.513	0.042	12.140	0.000	Supported
H_{12}	COMPT -> PU	0.752	0.764	0.101	7.457	0.000	Supported
H_{13}	COMPT -> PEU	0.518	0.528	0.103	5.015	0.000	Supported

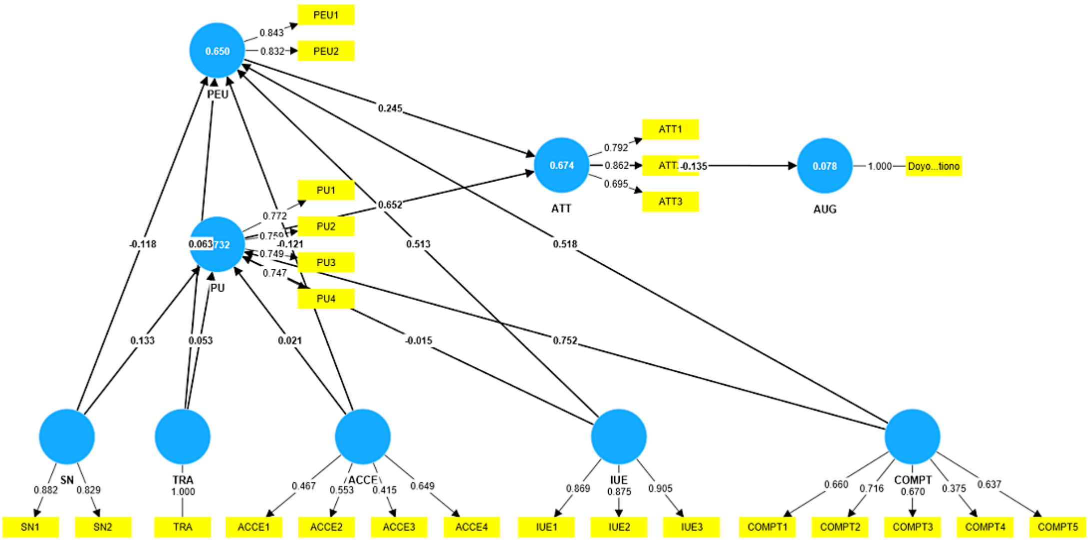

Fig. 2: Structural Equation Model path diagram for Endogenous and Exogenous variables

According to the tables, native elements yield very good outcomes, but external factors such as trail ability, accessibility, and the effectiveness of internet usage have no effect on the peasants' intentions to adopt. The idea that perceived usefulness and perceived ease of use are positively impacted by accessibility is unsupported. Likewise, there is no support for IUE on PU and TRA on PEU, PU.

The data indicates that farmers have a positive impression of embracing technologies.

Moderating Effect

Testing the moderating effects of peasants' education, place of residence, and amount of land held is the main goal of the second section of the SEM. Literature has demonstrated that education and land ownership have a substantial impact on people's inclination to use technology.[41, 42, 43]

Table 5.1: R-squared test Values for Endogenous Variables

Model	R-Square
ATT	0.674
AUG	0.078
PEU	0.650
PU	0.732

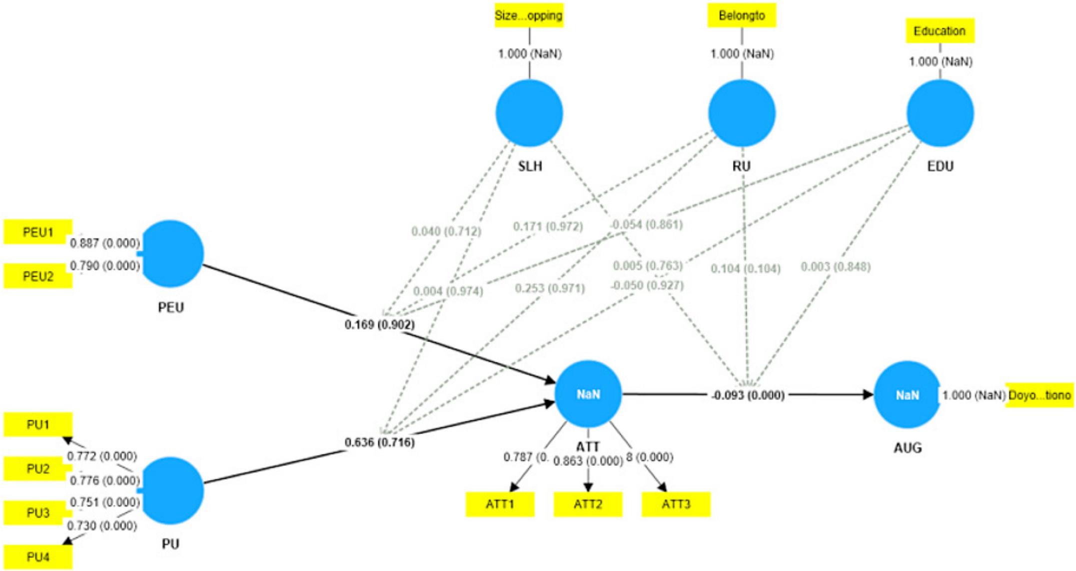

Fig. 3: Structural Equation model path diagram for moderating variables education, Rural &Urban and Size of Land Holding

Table 6: showing Moderate effect of Education, Place of Residence and Size of Landholding towards technology adoption

Path coefficients Mean, STDEV, T values, p values							
Hypot -hesis		Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	Decision Supported/ Not Supported
H_{14}	SLH x PU -> ATT	0.004	0.002	0.126	0.033	0.974	Not Supported
H_{15}	SLH x PEU -> ATT	0.040	0.041	0.108	0.369	0.712	Not Supported
H_{16}	SLH x ATT -> AUG	0.005	0.005	0.015	0.302	0.763	Not Supported
H_{17}	RU x PEU -> ATT	0.171	0.243	4.841	0.035	0.972	Not Supported
H_{18}	RU x PU -> ATT	0.253	0.231	6.998	0.036	0.971	Not Supported
H_{19}	RU x ATT -> AUG	0.104	0.107	0.064	1.625	0.104	Not Supported
H_{20}	EDU x PEU -> ATT	-0.054	-0.056	0.307	0.175	0.861	Not Supported
H_{21}	EDU x PU -> ATT	-0.050	-0.052	0.545	0.091	0.927	Not Supported
H_{22}	EDU x ATT -> AUG	0.003	0.002	0.018	0.192	0.848	Not Supported

From the table above, it is clear that any of the three factors under the consideration of moderating effect, i.e. Education, Place of residence (Rural and Urban) and size of land holding, has no significant influence on the perceptions of the individuals that can strengthen the relationship towards Technology Adoption. However, as discussed earlier, the indigenous variable has shown the same effect level. However, moderating factors do not help improve the adoption of new technologies in the agricultural sector among small and medium-sized peasants.

Discussion

The commercialization of innovations in India's agriculture industry is critical for increasing productivity, sustainability, and farmer livelihoods. Despite the benefits, farmers' embrace of new technologies varies greatly. Affordability, simplicity of use, availability to information, and faith in technology providers all impact adoption. Farmers with more knowledge or financial resources are more likely to adopt advances such as precision farming, biotechnology, and digital tools. Small and marginal farmers, who make up the vast majority, frequently confront difficulties owing to a lack of education, poor infrastructure, and financial restraints.

Endogenous constructs like Perceived Ease of Use, Perceived Usefulness of the model significantly affected the consumer attitude and Behavioural Intentions.[44] As per the TAM theory, the adoption of technologies is in three stage process. In which external factor that triggers cognitive processes that are system design features on PEU and PU, which in turn, influence use Behaviour.[45, 46] The proposed study is to understand perceptions of the peasants' intention towards Technology adoption in leveraging the absolute advance of technological innovation in the Agriculture Sector among the small and medium peasants. In this regard, the research is categorised into three levels. The first part of the Model includes the TAM Basic model of Davis 1986 focusing endogenous constructs PU and PEU. It continues to amalgamate other constructs as extraneous variables (SN, IUE, COMPT, TRA and ACC) in the second level of the Model to test their influence. Finally, the third stage tests the moderating effect of Education, Size of Land Holding, and Place of Residence of the individual in affecting the strength of the relationship.

In the present proposed Model in agriculture sector, it is clear that there is a positive significant relationship at the intention level while testing the Technology acceptance model. To substantiate, the Model has R^2 values as shown in the table-5.1 as well as in the figure-2, 65.0% for Perceived ease of Use (PEU), 73.2% for Perceived Usefulness (PU), and 67.4% for Attitude (ATT) of the peasants towards the adoption of technologies in the field of agriculture. However, the Actual usage (AUG) of the Technologies is very poor, resulting in a value of 0.78%, which is very insignificant and the weakest relationship in the Model. The studies also reveal that there is a slow penetration of technologies, where in sectors in which use of understanding is low like labour of construction filed with regard to Technologies utilisation.[47]

When analysed exogenous variables like compatibility (COMP) and social norms (SN) in the model, they are positively influencing the technology adoption. In the case of Accessibility (ACC), Internet usage efficacy (IUE), and Trailibilty (TRA) of Technologies in the field of agriculture are not supported. The size of land holding leads to increase in the investments. Further continuing Model to assess the moderating effect of education (EDU), size of Land Holding(SLH), and the domicile (RU) of peasants leading to influence positively towards Technological adoption resulted in insignificant.

Conclusion

It is evident from the study and findings that the peasants have a fairly positive perception of agricultural technologies. Unfortunately, there is a lack of actual adoption or penetration of digital technology among the peasantry. In the nation's isolated regions, the majority of small and medium-sized peasants require more sophisticated technologies. The sample is dominated by respondents with low levels of education or only a primary education, and it shows that the majority live in rural areas, which is representative of the people of India. Therefore, it is recommended that government agencies and private parties take the lead in reaching these populations. Only with government participation can digitalization be facilitated, reaching small business units and increasing efficiency through digitalization.

The growth and direction of new innovations in technology adoption can be influenced by the use of demand-pull (DP) and technology-push (TP) strategies. Nations with inadequate infrastructure must have sufficient facilities to showcase the benefits of digital technologies in the agriculture industry as elements that attract demand. With the help of start-ups like DeHaat, Reshamandi, CropIn, Aquaconnect, AgNext, and others, bright young minds from IITs and IIMs are bringing technologies closer to farmers by building clusters, linking disparate platforms, and offering suitable information systems in the field of agriculture. Only under that scenario will the benefits of digital technologies be seen in the agricultural sector's productivity and crop yields, particularly for small and medium-sized farmers.

Limitations of the Study and Further Research

The study's target population is small and medium-sized peasants; hence this group makes up the majority of the sample. The agricultural sector will not adopt technology for TAM fitting at a high rate. But there is still a lot to learn about this field by looking at different parts of the world and concentrating on Effect Size analysis through systematic examination and comparison with other sectors, including the agriculture industry.

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Conflict of Interest

The authors do not have any conflict of interest.

Data Availability Statement

The data will be provided based on the candidate's request, as the main sources of information analyzed are through questionnaire, are readily available.

Ethics Statement

This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Clinical Trial Registration

This research does not involve any clinical trials.

Author Contributions

The sole author was responsible for the conceptualization, methodology, data collection, analysis, writing, and final approval of the manuscript.

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