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A Multivariate Analysis of Agricultural Electronic Trading Adoption

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The study addresses the knowledge gap related to the scarce literature on digitalization in India's agricultural marketing. A field survey of five hundred National Agriculture Market users is undertaken to understand the theoretical constructs of wholesale electronic trading adoption in a realistic backdrop of a large digital project. The Partial Least Squares-Structural Equation Modelling (PLS-SEM) methodology is used for the statistical analysis. It demonstrates the positive effect of variables: 'Trust', 'Cost', 'Social Influence', 'Perception-Ease of Use', 'Perception-Usefulness', and 'Facilitating Conditions' on the adoption. The study brings out a simple agricultural wholesale e-trading adoption framework. It extends the existing theoretical knowledge base concerning technology adoption in new contexts (wholesale electronic trading, agriculture, India). It expands the scope of the theory by adding new constructs, 'Trust' and 'Cost'. The study's recommendations are expected to help practitioners in decision-making. It shall help practitioners of developing countries prioritize using scarce resources to deliver the intended benefits to the farming community in terms of administrative ease, user convenience, expanded market reach, faster cycle time,

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Introduction

The digitalization trend is evident in the agriculture sector. The interaction of fast-changing latest Information and Communication Technology (ICT) and the oldest profession (agriculture, traditional ecosystem) opens multiple issues. Digitalizing the business-to-business (B2B) procurement stage is essential to improving the agricultural supply chain.

Digitalization in the Procurement

In the procurement stage, agricultural commodity sales are progressively changing from the verbal public sale (auction) mode to the digital e-trading mode in India. Wholesale e-trading platforms are more open and transparent than physical markets. E-trading has accelerated and expanded the procurement process. It is also expected to strengthen the seller's bargaining power by giving them online reach to intra-market, inter-market, and inter-state buyers. As a result, farmers are set to receive a higher price when selling produce to the markets with shortage/high demand through the online e-trading platform rather than through a limited number of regional agents at the farm gate.[1,2]

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The research focus is derived from the empirical finding that the B2B e-commerce platforms such as electronic trading (e-trading) shall focus first on building a critical number of users (farmers, traders) and quality. As the number of users/transactions on the e-commerce platform grows to the critical number, the platform becomes viable and more valuable to other stakeholders. The other stakeholders include application developers, exporters, transporters, logistics and value-add service providers.[3]

Post literature review, the research gaps are identified as follows: Research on the agricultural B2B e-commerce (e-trading) adoption is scarce, the case studies on agricultural e-trading are few, and there is little research in India on agricultural e-trading benefits for farmers. By responding to the following queries, the research gaps can be filled: What are the driving factors behind adopting e-trading in the Indian agricultural sector? Using the learning from the case of the National Agriculture Market (eNAM)[4], how can the adoption of e-trading be promoted? These research questions led to the research objective of this study.

Research Objectives

Consequently, the study has the following objectives:

- To validate the agricultural e-trading adoption framework in the National Agriculture Market context.
- Make suggestions for ways to increase wholesale agricultural e-trading adoption.

Proposed Framework

For validation, the proposed adoption framework for agricultural e-trading in India (Fig. 1) is generated using the Total Interpretive Structural Modelling (TISM) methodology.[5] It is the extended form of the Unified Theory of Acceptance and Use of Technology (UTAUT).[6,7]

The seven latent variables (Constructs) are construed as significant direct or indirect determinants of adoption in agricultural wholesale trading (Table 1). The constructs are considered, analyzed, and eventually managed in the agricultural sector adoption context.

The null and alternative hypotheses are conceptualized as follows:

H_{01}: 'Perception -Usefulness' does not have an effect on the 'Behavioural Intention' to adopt the e-trading platform.

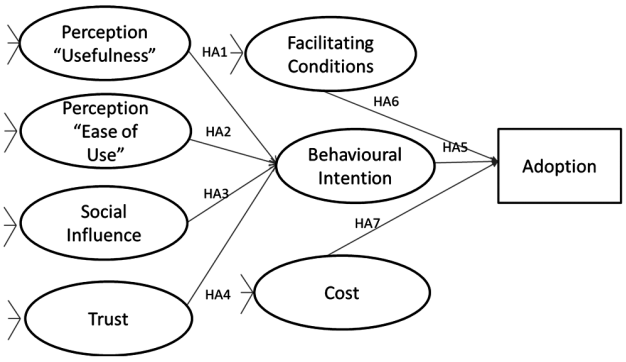

Fig. 1 — Proposed adoption framework

H_{A1}: 'Perception - Usefulness' have an effect on the 'Behavioural Intention' to adopt the e-trading platform.

Similarly, the null hypothesis H_{0I} will follow the same form, where I = {2, 3, 4, 5, 6, and 7} for the null hypotheses against which the alternative hypotheses are:

H_{A2}: 'Perception - Ease of Use' have an effect on the 'Behavioural Intention' to adopt the e-trading platform.

H_{A3}: 'Social Influence' have an effect on the 'Behavioural Intention' to adopt the e-trading platform.

H_{A4}: 'Trust' have an effect on the 'Behavioural Intention' to adopt the e-trading platform.

H_{A5}: 'Behavioural Intention' have an effect on the 'Adoption' of the e-trading platform.

H_{A6}: The 'Facilitating Conditions' have an effect on the 'Adoption' of the e-trading platform.

H_{A7}: 'Cost' has an effect on the 'Adoption' of the e-trading platform.

Materials and Methods

The Partial Least Squares-Structural Equation Modelling (PLS-SEM) method, a statistical analysis technique of the primary survey data, is used to numerically validate the proposed framework and confirm the key driver constructs for the dependent variable 'Adoption'.

PLS-SEM is preferred over Covariance-Based Structural Equation Modelling (CB-SEM) for data analysis for two reasons. First, the exploratory study aims to identify key driver constructs. Second, the data for the nominal dependent variable ('Adoption') are not normally distributed.[25,26]

Table 1 — Constructs in the research framework

Code	Construct	In-Study Explanation	References
PU	Perception - Usefulness	eNAM provides users with benefits such as quality transparency, better pricing, and faster market transactions.	6, 8, 9, 10, 11
PEU	Perception - Ease of Use	eNAM is easy to learn and simple to use	9, 10, 11, 12, 13
SI	Social Influence	eNAM is endorsed and promoted by a community of acquaintances, pioneering farmers, affiliated traders, and community leaders.	6, 11, 12, 14, 15
T	Trust	User confidence in eNAM portal content, trade, and information. It is also a belief that the eNAM is credible. Farmers and other stakeholders stand to gain from the management's activities.	12, 13, 16, 17, 18, 19
C	Cost	Transaction Costs on the eNAM platform	12, 19, 20, 21
FC	Facilitating Conditions	The infrastructure, which includes electronic weighing, quality test laboratories, auction halls, logistics facilitation, training, and customer service, supports the use of eNAM.	6, 11, 22, 23, 24
BI	Behavioural Intention	The extent to which a farmer/trader has made a deliberate plan to e-trade.	6, 7, 9, 22
U	Adoption	Actual usage of eNAM	6, 7, 9, 22

A case study of the eNAM wholesale e-trading platform provides practical context to validate the proposed framework's theoretical basis.[27] The eNAM is the government-supported de-facto pan-country platform that is much larger in scope and size than the platform launched by the corporates. It is expected to reach all 7,320 Agricultural Produce & Livestock Market Committee (APMC) market and sub-market yards over the next five years. It has registered 17.3 million farmers, 0.22 million traders, and two thousand one hundred forty Farmer Producer Organizations (FPOs), with cumulative trade reaching INR 1220 billion by February 2021.[(4)] The inter-market and inter-state trade of 175 commodities are possible on this platform. The recommendations to improve eNAM adoption are based on an understanding developed through the study and the interviews with experts.

Five APMC markets in two states, viz. Uttar Pradesh (Aligarh, Pilibhit, and Meerut) and Rajasthan (Nagar, Nadbai) were selected for primary data collection. These APMCs: experience many transactions, a considerable size, a large user base, and trade in similar commodities.

A structured questionnaire was developed in the local language, i.e., Hindi, with the help of a person with good knowledge of the language and agriculture. Two experts reviewed the draft questionnaire for language and content. The specific questions were modified as per the context of the study, keeping the previous research in view.[6,7] The final questionnaire measured 22 items on a 7-point Likert scale, where one implied 'No Influence' and seven meant 'Extreme Influence'. The questionnaire was subjected to internal consistency improvement and context-specific adjustments based on a pilot study involving 70 respondents.

The primary data was collected from the field survey with a sample size of 500 respondents. The sampling unit is the farmer registered on the eNAM portal at the APMC. The respondents are randomly selected via a random selection from the sampling frame (database in excel format) of registered farmers maintained by the five APMCs. It is expected that as a registered user of eNAM-enabled APMC, the respondent has an opinion about its functioning. The bias was eliminated, as all farmers had an equal chance of being chosen. The survey was conducted offline, either at the farmer's home or at the APMC location and over the course of one year starting in 2019. Although the process was time-consuming, it enjoyed a higher response rate from the rural population than surveys based on postal mail, telephone, or online mode.[28] The questionnaire responses were coded into Microsoft Excel and imported into SmartPLS 3.0 software for PLS-SEM analysis.

The sample size of 500 is adequate since SEM studies suggest a sample size of 200 as fair and 300 as acceptable. The G-Power software analysis recommended an appropriate sample size of 226.[25] Another suggestion is that the sample in multidimensional research is at least decuple the number of observed variables (survey items)[29,30], resulting in a reasonable sample size of 220.

Results and Discussion

The PLS-SEM based statistical analysis of the proposed framework is conducted in two steps: measurement model validation and structural model validation.

Demography and Data Characteristics

The 500 questionnaires were complete and considered for further analysis. The respondents were farmers registered at the following Agricultural Produce Market Committees (APMCs): Meerut, Aligarh, Nagar, Nadbai, and Pilibhit. Of 500 respondents, 42.6% dealt with vegetables, 29.4% dealt with wheat, 18% dealt with paddies, 6 dealt with mustard and 4% dealt with maize. The case study of the eNAM provides the survey data used to test the theory.

The model is recursive with no circular feedback loops. The observed independent variables are normally distributed. The model measures are reflective, where each of the six determinant latent constructs and one mediating determinant latent construct is made up of three observed independent variables. To ensure accuracy, the data have no missing values or outliers. The sample size of 500 is sufficient to give reliable PLS estimates.

Measurement Model Validation

The measurement model is assessed using PLS-SEM best practices. All the observed variables' item loadings are greater than 0.71, showing a good contribution to the assigned construct. It provides acceptable construct reliability. Because all the Composite Reliability (CR) values are between 0.80 and 0.90, the internal consistency reliability is determined to be good. Cronbach's alpha (α) values

are greater than 0.70, thus re-determining internal consistency reliability to be good. The Average Variance Extracted (AVE) checks for convergent validity. All the AVE values are greater than 0.50; thus, convergent validity is established.[31,32] Table 2 displays the reliability and validity assessment values.

The Fornell and Larcker (FL) criterion and the Heterotrait-Monotrait (HTMT) criterion are used to ascertain discriminant validity.[33,34] As each construct's AVE is greater than the squared inter-construct correlation of that same construct and all other reflectively measured constructs, the FL criterion is satisfied. The HTMT criteria are also met, as most of the calculated values in Table 3 are less than the recommended value of 0.9, indicating sufficient discriminant validity. A few exceptions are noted, as the respondents are farmers (at varying literacy levels) and, as such, might have faced problems in differentiating between the constructs.

Structural Model Validation

The structural model (Fig. 2) emphasizes the interrelationship of the research framework's constructs. The association is tested using path coefficients (β) and t-statistics.

Most of the Variance Inflation Factor (VIF) values are less than three, and almost all are less than 5. Thus, the collinearity between the predictor constructs does not bias the regression results. The dependent constructs' 'Behavioural Intention' (BI) lowest coefficient of determination (R^2) value is 0.67, a near substantial value in behavioural sciences research. The value of R^2 for the primary dependent variable

Table 2 — Reliability and validity assessment

Construct	Observed Variable (Item)	Item Loading	Composite Reliability (CR)	Cronbach's Alpha (α)	Average Variance Extracted (AVE)
Perception – Usefulness (PU)	Useful in Trade (PU1)	0.94	0.9	0.9	0.85
	Accomplish Task Quickly (PU2)	0.93			
	Price Increase (PU3)	0.89			
Perception – Ease of use (PEU)	Good User Interface (PEU1)	0.89	0.9	0.85	0.78
	Easy to use (PEU2)	0.88			
	Easy to Learn (PEU3)	0.89			
Social Influence (SI)	Influencers (SI1)	0.88	0.87	0.78	0.69
	Helpful Management (SI2)	0.80			
	Organization support (SI3)	0.82			
Facilitating Condition (FC)	Infrastructure (FC1)	0.91	0.9	0.86	0.78
	Training (FC2)	0.89			
	Support (FC3)	0.87			
Trust (T)	Accurate Information (T1)	0.93	0.9	0.9	0.84
	Trust in Seller (T2)	0.92			
	Trust in Buyer (T3)	0.91			
Cost (C)	Transaction cost (C1)	0.87	0.86	0.76	0.67
	Value for Money (C2)	0.83			
	Overall Cost (C3)	0.76			
Behavioural Intention (BI)	Intend - with 3 months (BI1)	0.82	0.88	0.79	0.7
	Intend -within 1 year (BI2)	0.90			
	Intend – no time-period specified (BI3)	0.81			

Table 3 — Discriminant validity

	Fornell and Larcker Criteria							HTMT Criteria						
	BI	C	FC	PEU	PU	SI	T	BI	C	FC	PEU	PU	SI	T
BI	0.84													
C	0.86	0.82						1						
FC	0.76	0.78	0.89					0.9	0.9					
PEU	0.71	0.76	0.80	0.88				0.8	0.9	0.9				
PU	0.73	0.77	0.79	0.85	0.92			0.8	0.9	0.8	0.9			
SI	0.70	0.75	0.77	0.80	0.78	0.83		0.8	0.9	0.9	0.9	0.9		
T	0.79	0.86	0.79	0.76	0.80	0.74	0.92	0.9	1	0.8	0.8	0.8	0.8	
U	0.79	0.81	0.70	0.73	0.72	0.68	0.71	0.8	0.9	0.7	0.7	0.7	0.7	0.7

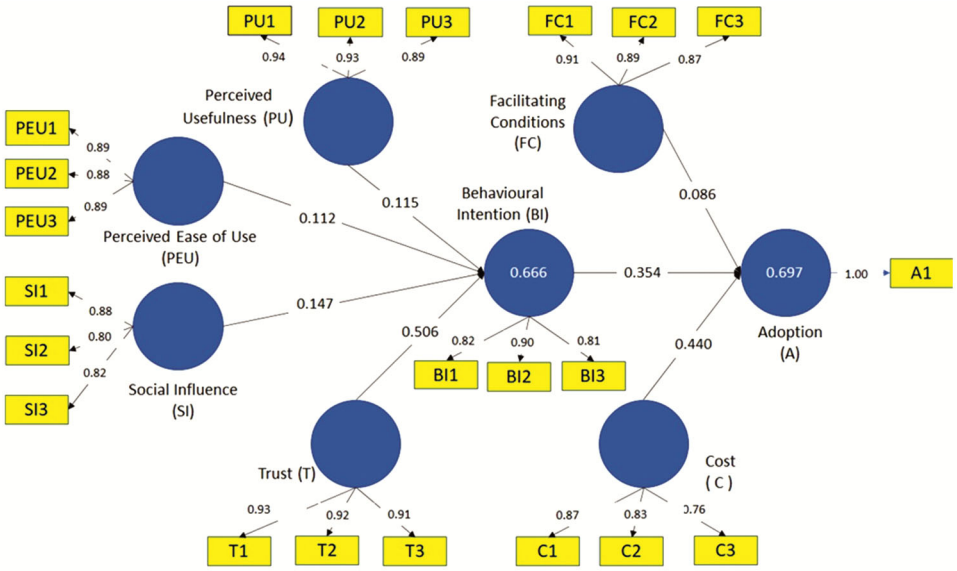

Fig. 2 — Structural model of adoption framework

Abbreviations: *Perceived Usefulness (PU), Perceived Ease of Use (PEU), Social Influence (SI), Trust (T), Cost (C), Facilitating Conditions (FC), Behavioural Intention (BI), Adoption (U).*

'Adoption' (U) is higher at 0.70, indicating that the model accounts for a large proportion of the dependent variable variance. The structural model has a near substantial in-sample explanatory power.[35] The structural equation's R^2 values and PLS-SEM fit indices are presented in Table 4.

The Non-Fuzzy Index (NFI) value is 0.81, and the Standardized Root-Mean-Square residual (SRMR) value was 0.064. The model for the adoption framework is a good fit since the SRMR value is less than 0.08 and NFI is 0.8.[36]

The PLS-SEM results for the structural model of the adoption framework (Fig. 2) are presented in Table 5. For significant P values < 0.05, all the hypotheses (Table 5) are supported. The path coefficients are also given in Table 5.

The relationship between the constructs is significant, as all the t values are more than 1.96.

The Stone-Geisser criterion (Q^2) is used to evaluate the model's predictive relevance. It assesses the model's reconstruction of observed values and parameter estimates. The model must have a Q^2 greater than zero to be of predictive relevance. Q^2 values ('Adoption' at 0.66, 'Behavioural Intention' at 0.66) are above the zero-threshold value, indicating that the PLS path model for the adoption framework has high predictive accuracy.[18]

As for the f^2 effect sizes, the construct 'Cost' has a moderate effect on the 'Adoption', whereas the 'Trust' has a moderate effect on the 'Behavioral Intention' since the f^2 size effect is more than 0.15 but less than 0.35. Rest other constructs have a small effect since the F^2 effect size is less than 0.15. The 'Behavioural Intention' partially mediates the relationship between the constructs 'Social Influence' - 'Adoption' and 'Trust' - 'Adoption' with a p-value less than 0.05 and the indirect effects 95% boot confidence interval bias-corrected does not straddle a zero in between lower limit and upper limit[37], for other constructs 'Perception – Ease of use', and 'Perception – Usefulness', the effect pass through 'behavioural intention' and there is full mediation.

Table 4 — PLS-SEM fit indices

Model Elements	Values
R-square for Behavioural Intention BI)	0.67
R-square for Adoption (U)	0.7
Chi-square	1991
SRMR	0.064
NFI	0.8

Discussion

Concerning the first research objective, the adoption framework is successfully tested using a multistage analysis and found suitable.

Observations on the framework

The construct's manifestation in the respondent sample group of farmers differs from other Industry

Table 5 — Structural results

Hypotheses	Notation	Path Coefficients	t-Values	P-Values	Remarks
H_{A1}: 'Perception - Usefulness' have an effect on the 'Behavioural Intention' to adopt an e-trading platform.	PU→BI	0.119	2.016	0.044	Supported*
H_{A2}: 'Perception - Ease of Use' have an effect on the 'Behavioural Intention' to adopt the e-trading platform	PEU→BI	0.111	2.168	0.031	Supported*
H_{A3}: 'Social Influence' have an effect on the 'Behavioural Intention' to adopt the e-trading platform.	SI→BI	0.145	3.134	0.002	Supported*
H_{A4}: 'Trust' has an effect on the 'Behavioural Intention' to adopt the e-trading platform.	T→BI	0.504	9.610	0.000	Supported*
H_{A5}: 'Behavioural Intention' has an effect on the 'Adoption' of the e-trading platform.	BI→U	0.348	6.301	0.000	Supported*
H_{A6}: The 'Facilitating Conditions' have an effect on the 'Adoption' of the e-trading platform.	FC→U	0.088	2.110	0.035	Supported*
H_{A7}: 'Cost' has an effect on the 'Adoption' of the e-trading platform.	C→U	0.443	9.271	0.000	Supported*

*Significant at P-values < 0.05 and t-values > 1.96 (at the 5% significance level).

groups. The adoption framework is distinct as, unlike other sectors, the agriculture sector is characterized by a lack of ecosystem enabling infrastructure, low education level of farmers, and low digital/ information technology awareness among the rural population. The validated adoption framework adds to the existing knowledge base by redefining constructs, adding two new constructs ('Trust' and 'Cost') to the UTAUT, and altering the strength of relationships between constructs.

The model accounts for 70% of the variance for the dependent variable 'Adoption'. The variance explained is better than most other competing models. The variance explained for the dependent variable in the competing models are Innovation Diffusion Theory (IDT) - 40%, Technology Acceptance Model (TAM) - 53%, Theory of Planned Behaviour (TPB) - 36%, and Theory of Reasoned Action (TRA) - 36%. Comparatively, the Unified Theory of Acceptance and Use of Technology (UTAUT) explains about 70% of the variance (adjusted R2) in usage intention[6] with four direct determinants latent construct, that is, two less determinant latent constructs used in this study. However, more studies based on the validated framework of this study may be conducted.

The collation of discussions with experts and the study analysis resulted in the following strategic and tactical recommendations in connection with the second research objective.

'*Perception – Usefulness'* may be improved by unifying the state and national markets in a single legal framework. The full benefits of the digital platform may be realized in inter-market and interstate market transactions. Such Intermarket trade is to be streamlined with the disagreement resolution at the trade-originating APMC. Farmers are looking for a quick transaction cycle and a favourable price impact. The spread of mobile applications and prompt digital payment is expected to be a positive step. *'Perception - Ease of Use'* may be enhanced by making the e-trading portal/website user-friendly and providing multilingual content. Users like the mobile app, but it has to improve its interaction with other government and partner applications.

Local agri-community active participation may facilitate the improvement of '*Trust*.' Regular community awareness camps and FPOs involvement may help in this regard. The '*Facilitating Conditions*' too need improvement. Quality test labs, commodity parameters, robust mechanisms, public computer terminals, electronic weighing machines, and trade hall with Wi-Fi Internet connectivity are available in APMCs, but under suboptimal or bare essential conditions. Storage and logistics facilities may be enhanced by the involvement of Indian Railway freight discounting. There is, as of now, no periodic appraisal of skills and competency. The implementing agency may choose to build user capacity through regular online/offline training. According to experts, rather than relying on the existing APMC management and staff, a dedicated contact centre and on-the-ground eNAM staff may improve customer care, problem resolution, and conflict management.

Increasing influencer farmer and lead trader participation in eNAM may improve *'Social Influence*'. The scope of offerings and range of services on the eNAM platform may be widened, e.g.,

farm equipment trade/rent. The eNAM platform is based on an open technical standard. The scope of offerings and range of services may be widened, identical to the Aadhar/UPI scheme. It may release its open Application Programmable Interface (API) to the public. The open API will make it easily discoverable and interoperable with numerous related applications. From a social welfare perspective, it is wise to open a more significant portion of the eNAM platform and open intellectual property rights to the public.[38]

The lower the transaction '*Cost*', the higher the '*Adoption*' of the eNAM wholesale e-trading platform. The inequity between taxes and market fees across states impedes inter-state agricultural produce transactions. Some uniformity across APMCs in different forms may result in greater user adoption of interstate trade, which has been launched on the e-trading platform. Furthermore, to compete with commission agents' informal credit system and cartels, registered farmers may be given favourable bank credit terms, access to innovations like warehouse receipt, and lifecycle-linked inter-agency credit recovery. The traders may be given flexible credit terms for buying and selling on eNAM.

Conclusions

In the Indian agriculture sector, eNAM is a high-priority strategic intervention. The adoption framework proposed and validated in this article may aid in adopting wholesale e-trading through improved organizational readiness and recommended steps to strengthen adoption enablers among farmers. The 'Trust', 'Cost', and 'Social Influence' are identified as the significant constructs and enablers of adopting the Wholesale e-trading initiative (eNAM). Other enablers have been identified as 'Perception-Ease of Use', 'Perception-Usefulness', and 'Facilitating Conditions'. The study's recommendations are expected to help practitioners effectively deliver intended benefits to the farming community in terms of administrative ease, reduction in transaction cost, quick trade cycle, and better price realization. The theoretical details and the knowledge base generated in this study are expected to be beneficial to the researchers. The results may be refined and enriched based on learning from further studies in this direction.

Digitalization via e-trading will transform the existing agricultural marketing and supply chain activities approaches. e.g., collection, grading, trading, storage, packaging, and transport. It is expected to aid in resolving the issue of fragmented and inefficient agrarian supply chains and facilitate the ease of business and socio-economic growth of the farming community.

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