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Digital Awareness and Technology Adoption Among Rural Households: An Empirical Analysis of Socio-Economic Determinants

[1]Dr. Deeppa Krishnaswamy, [2]Dr. Nandini Jagannarayan, [3]Dr Sampurna Nand Mehta, [4]Dr. Mala Goplani

[1]Associate Dean, IBS Pune,Maharashtra,India

[2]Assistant Professor, Hindi Vidya Prachar Samiti's Ramniranjan Jhunjhunwala College of Arts, Science and Commerce (Empowered Autonomous), Ghatkopar, Mumbai, Maharashtra, India

[3]Associate Professor, Thakur College of Engineering and Technology (TCET), Mumbai, Maharashtra, India

[4]Assistant Professor, Hindi Vidya Prachar Samiti's Ramniranjan Jhunjhunwala College of Arts, Science and Commerce (Empowered Autonomous), Ghatkopar, Mumbai, Maharashtra, India

Abstract

Digital technologies are a part of education, finance, health, agriculture, governance and communication. While technology has advanced quickly, gaps in the digital awareness and adoption of technology remain, especially in rural areas. This study examines socio-economic factors affecting the digital awareness and the use of technology by rural households. The 60 respondents gave primary data which were analysed with descriptive statistics, Chi-square analysis, independent sample t-test, one-way ANOVA, binary logistic regression and path analysis. The results indicate that education positively affects digital awareness and occupation has a positive effect on technology adoption and preferences for digital services. Gender differences were found in access to digital technologies, but not gender in the regression model for digital awareness. The results of the path analysis show that education has a positive effect on digital awareness and then towards technology use and digital empowerment. The study underscores the need for digital literacy programmes, cost-effective and affordable internet infrastructure and inclusive technology policies to lessen the digital divide and support sustainable rural development.

Keywords: Digital Literacy, Technology Adoption, Digital Awareness, Digital Inclusion, Rural Development, Technology Acceptance

Introduction

This has greatly enhanced access to information, financial services, education, healthcare, governance and employment in modern societies, as digital technologies have advanced at an unprecedented pace. Mobile phones, the cloud, artificial intelligence (AI), Internet of Things (IoT), blockchain and digital payment have all contributed to improve the economic productivity and social connectivity. To foster inclusive growth and more effective public service delivery, and to narrow socio-economic gaps, digital transformation (DX) has been the key priority of governments around the world.

The digital India program has significantly enhanced internet connectivity and digital infrastructure in rural and urban areas in India. There remains significant differences in digital awareness, access, affordability and effective use of technology, however. Rural areas may have low levels of digital literacy, underdeveloped infrastructure, weak internet connectivity, lower education levels, and socio-economic limitations which are preventing them from accessing the digital economy.

Education is known to be one of the most powerful drivers of digital literacy and the education system is a key pathway for the spread of digital literacy.The education sector is a well-documented pathway to digital literacy and driving force in uptake of new technologies, access to online information and use of digital platforms for education, business, banking, healthcare and communication. In a similar way, the type of work that people do affects technology use; service workers tend to show higher exposure to digital tools than do people who work in agriculture or in the informal sector. Differences in access to digital technology, digital skills, and social norms in terms of age and gender are also expected to influence digital technology adoption.

Knowledge of socio-economic factors influencing digital awareness and technology uptake is key to creating efficient policy and strategy to ensure digital inclusion and to close the digital divide. Thus, the present study explored the relationship between education, occupation, gender and age with awareness about digital devices and use of technology by rural households by applying descriptive and inferential statistical methods.

Review of Literature

A relatively systematic review of literature should not be limited to summarizing the literature on digital technology adoption for an economics journal. Rather, it should illustrate the development of economic theory to account for digital awareness, technologies uptake and digital inclusion. The results of your empirical research can then be placed as a continuation of this theoretical development. The review should be based from the classical economic theory to the present digital economic theory.

This paper examines the literature systematically from an economics point of view.This paper provides a systematic review of literature from an economics perspective.

Human Capital Theory and Adoption of Digital Technology.

An economic explanation of technology adoption starts with the Human Capital Theory of Becker (1964), which states that education and skill acquisition are investments to boost productivity and income. Recent research of digital literacy more and more defines it as an extension of human capital, since it allows for the improvement of the individual's capacity to acquire, process, and use information in the digital economy.

The most recent empirical data clearly shows that education has a meaningful impact on digital awareness and uptake. Countries with higher levels of education have significantly higher rates of digital participation and ICT use (OECD, 2021). The World Bank (2021) also claimed that digital skills are an economically valuable skill that can be used to complement or replace conventional schooling and job training.

The relation has been confirmed by several empirical studies. Van Deursen and Van Dijk (2021) concluded that education has a positive impact on digital competence, which in turn positively influences access to digital services. Cruz-Jesus et al. (2022) showed that digital literacy has a significant positive effect on engaging in digital financial services and online markets. More recently, OECD (2024) highlighted that investment in digital skills leads to measurable benefits for labour productivity and welfare of the household.

Overall, these research efforts show that education is effective in boosting information processing capacity, technology self-efficacy, and cognition related to digital awareness. The present study furthers this literature by showing that education continues to be the paramount determinant of digital awareness for rural households, which are the subjects of this study, thus supporting the assertions of Human Capital Theory.

Information Economics & Digital Awareness

Spence (1973), Stiglitz (2000) and Akerlof (1970) set out to explain how imperfect information causes market inefficiencies, adverse selection and increases transaction costs. Digital technologies can minimize these inefficiencies by making information more accessible and search cost less.

In recent economic literature digital inclusion is often referred to as Information Economics. Digital technologies can greatly alleviate information asymmetry, particularly in terms of access to market information, financial services, health care, and government programmes, Goldfarb and Tucker (2019) contended. The World Bank (2021) also highlighted the fact that digital platforms eliminate information barriers, allowing households to take more efficient economic decisions.

Empirical research on digital awareness by Hjort and Poulsen (2019), OECD (2023) and UNDP (2023) shows that by reducing information barriers, digital awareness increases labour market participation, financial inclusion and entrepreneurial activities.

This theoretical approach is confirmed by the present study, which revealed that the digital awareness of households is associated with their use of digital technologies to reduce the information asymmetry and enhance their socio-economic participation.

The theory of transaction costs and the theory of technology adoption.

The Transaction Cost Economics (Coase, 1937; Williamson, 1985) theory suggests that economic agents choose institutional structures and technologies in order to reduce transaction costs.

The costs of searching for information, travelling, banking, communication, and of participating in markets are significantly lowered by digital technologies. New research has proved that the use of digital payments, mobile banking, e-commerce and electronic governance reduces transaction costs, especially in rural economies.

Jack and Suri (2016) found that mobile money helped lower transaction costs and boosted household resilience. The World Development Report (2021) highlighted that digital infrastructure reduces coordination costs, and brings economic efficiency. The same is observed in the context of digital government services by OECD (2024), which indicated that digital government services deliver public services and lower administrative costs.

In this regard, the present study adds to the literature by establishing that digital awareness by education leads to higher adoption of technology and thus supports rural households in lowering economic transaction costs and their welfare.

To foster Digital Inclusion, it is essential to adopt a Capability Approach.

In 1999, Amartya Sen introduced his Capability Approach, which made a paradigm shift in development economics from income growth to the growth of individual capabilities and freedoms. Digital technologies have been identified as increasingly important resources or means that enhance capabilities and provide greater access to education, health, financial and governance services, and employment.

The term digital inclusion is found in recent literature as a key factor in human development. According to UNDP (2022), digital competence has emerged as a new form of social inclusion. In addition, Van Dijk (2020) recommended that digital participation is not only associated with infrastructure but also with people's capacity to effectively utilize technology.

Empirical research by Helsper (2021) and OECD (2024) indicates that digital literacy has positive effects on economic participation, financial empowerment and social mobility.

The results of the present study corroborate this view, showing that education has positive effects on digital awareness, and that digital awareness, in turn, has positive effects on technology use and digital empowerment among rural households.

Digital Divide Theory and Socio-economic Inequality.Digital Divide Theory and Socio-economic Inequality.

Digital Divide Theory describes the socio-economic disparities in access, skills, use and outcomes. Previous research has concentrated mainly on access to the internet, but recent research has been able to identify the importance of three other factors: education, occupation, and digital skills.

Van Dijk (2020) suggested that digital inequality is a process of four stages: motivational access, physical access, skills access, and usage access. According to OECD (2023), the level of education is still, in both developed and developing countries, the most important factor for digital inclusion.

ITU (2023), World Bank (2022), and UN DESA (2023) have recently gathered empirical evidence to show that educational attainment is a much stronger predictor of digital participation than other demographic characteristics, like gender.

The results of the present research support this literature, revealing that education and occupation are important factors affecting digital awareness and technology use, while gender was not statistically significant when holding constant for socio-economic factors.

This paper will examine how the Technology Acceptance Model and Diffusion of Innovations theories can be applied in economic settings.This paper will explore the application of the TAT and DOI theories in economic contexts.In addition to the development in information systems research, the Technology Acceptance Model (TAM) (Davis, 1989) and Diffusion of Innovations Theory (DIT) (Rogers, 2003) have begun to be used in

economic analyses of digital adoption more and more. Theories about perceived usefulness, ease of use and communication channels affect the spread of technology, and economic theories provide explanations for why people have the ability and motivation to use technology.

An integration of TAM with Human Capital Theory has been recently reported as showing that with each further step of education, digital competence rises, which enhances perceived usefulness and ease of use, leading to greater adoption of technology (Al-Emran et al., 2022; Dwivedi et al., 2023). Likewise, Rogers' diffusion theory indicates that socio-economic status and education speed the rate of innovation uptake by diminishing the uncertainty of the innovation.

In the present study, these behavioural approaches have been combined with the economic theories by showing how education builds human capital, increases awareness and attitudes towards digital literacy and then leads to technology adoption and digital empowerment.

The literature was synthesized and a research gap was identified.Literature was synthesized and a research gap was identified.

The systematic review shows that the literature of economics has increasingly shifted from the view that education is a means of improving productivity as an investment, to the one which acknowledges that digital awareness is fundamental to human capital. The Human Capital Theory clarifies how education can build digital skills; the Information Economics approach emphasizes the importance of creating a digital awareness for reducing information asymmetry; the Transaction Cost Economics approach shows how digital technology can lower the costs associated with market participation; and the Capability Approach situates digital inclusion as an avenue for increased human freedoms and welfare. In addition to these economic viewpoints, there are a number of theories that inform the study of digital access and the behaviour of adopting new technologies, such as the Technology Acceptance Model and the Diffusion of Innovations Theory, which highlights persistent socio-economic disparities in access and access use, and explain the mechanisms by which people take up new technologies respectively.

Although these are theoretical advances, there are three important gaps. First, much of the available evidence comes from developed countries, and few empirical studies of rural households in developing countries, like India. Second, previous research tends to explore digital awareness and/or technology adoption without modelling the transition from socio-economic factors to digital awareness to technology use to digital empowerment. Third, very few studies combine classical economic theories with technology adoption models in one analytical model. In response to these gaps, the present study introduces an integrated economic approach in which education is seen as an investment in human capital, digital awareness is seen as a way to save on information and transaction costs, technology adoption is considered as an improvement of individual capabilities and digital empowerment is part of inclusive rural development. This holistic view leads to a clearer economic basis of how households in rural areas are utilizing technologies.

Table 1 Alignment of Research Objectives, Hypotheses, Economic Theories, and Statistical Techniques

Objective	Hypothesis	Economic Theory	Statistical Technique
To examine the socio-economic profile and level of digital awareness and technology adoption.	Descriptive	Human Capital Theory	Descriptive Statistics

To analyse the influence of education, age, occupation, and gender on digital awareness.	H_{01}, H_{05}	Human Capital Theory	Chi-square, ANOVA, Logistic Regression
To investigate the relationship between digital awareness and technology adoption.	H_{03}	Information Economics, Technology Acceptance Model (TAM)	Correlation /Path Analysis
To examine the effect of technology adoption on digital empowerment.	H_{04}	Capability Approach	Path Analysis
To identify socio-economic determinants of digital awareness.	H_{05}	Human Capital Theory	Binary Logistic Regression
To examine the pathways linking education, digital awareness, technology adoption, and digital empowerment.	H_{06}	Human Capital Theory, Information Economics, Transaction Cost Economics, Capability Approach, TAM, Diffusion of Innovations	Path Analysis / Structural Model

Note Source :Compiled by the authors based on Gary S. Becker (1964), George A. Akerlof (1970), Oliver E. Williamson (1985), Fred D. Davis (1989), Amartya Sen (1999), Everett M. Rogers (2003), and Andy Field (2024).

Variable Description

Dependent Variable – Digital Awareness (Aware / Not Aware)

Independent Variables –Education, Age, Gender, Occupation, Internet Accessibility, Smartphone Ownership, Digital Skills

Results and Discussion

Table 2: Demographic Profile of Respondents

Variable	**Category**	**Frequency (N)**	**Percentage (%)**
Gender	Male	31	51.7
	Female	27	45.0
	Other	2	3.3

Education	No Formal Education	10	16.7
	Primary	14	23.3
	Secondary	18	30.0
	Higher Secondary	9	15.0
	Graduate & Above	9	15.0
Occupation	Agriculture	24	40.0
	Casual Labour	16	26.7
	Service	10	16.7
	Others	10	16.7

Note. Source: Author's analysis based on Primary data collected from survey

The socio-economic profile of the respondents gives insight into the socio-economic aspects that influence digital awareness and technology use. Sixty people responded, with 51.7% identifying as male, 45.0% as female and 3.3% as other genders. In terms of education, most had secondary education (30%), a smaller proportion had primary education (23.3%) and few were graduates (15%). The study area was predominantly agrarian with agriculture being the main occupation (40%) followed by casual labour (26.7%).

From a human capital standpoint, these demographic attributes represent different levels of human capital among rural households. Human Capital Theory states that education increases people's productive capacity, increases access to information, and enables the use of technology. The majority of respondents who only have primary and secondary education implies that digital literacy interventions are still needed to boost participation in the digital economy. Similarly, occupational inequalities mean that there are differing levels of exposure to digital technologies: those working in the service sector tend to have more interaction with digital technologies than do those in agriculture. The results inform the context of the analysis of the socio-economic features that affect digital awareness and technology use.

Table 3: Measures of Central Tendency

Variable	Mean	Median	Standard Deviation
Age	38.5	36	12.4

Note. Source: Author's analysis based on Primary data collected from survey

The mean age of the respondents was 38.5 years and standard deviation was 12.4 years, suggesting that the majority of the respondents were in economically active age groups. The proximity of the mean and the median (38.5 and 36, respectively) indicate that the distribution of age is not strongly skewed.

Economically active people are likely to be more exposed to employment opportunities, financial services, agricultural innovations and digital platforms. The Human Capital Theory would argue that the incentives to learn digital skills would be greater in the economically productive age groups, given that technological knowledge contributes to increased labour productivity and opportunities for income generation. However, age can be anticipated to have an impact on digital awareness, albeit less pronounced than education when other socio-economic factors are taken into account.

Table 4: Cross-tabulation (Education × Digital Awareness)

Education Level	Aware (%)	Not Aware (%)	Total
No Formal Education	25	75	100
Primary	40	60	100
Secondary	65	35	100
Higher Secondary	75	25	100
Graduate & Above	85	15	100

Note. Source: Author's analysis based on Primary data collected from survey

As can be seen from the cross tabulation, there is a clear positive relationship between education and digital awareness. The awareness of digital raised progressively from 25% of users with no formal education to 85% of graduates. On the other hand, the higher the level of education, the more likely that digital unawareness decreased.

The result is robust support for the Human Capital Theory, which posits that education enhances an individual's knowledge, cognitive ability and productive skills. Education helps people access digital technologies, assess online information, and use digital platforms safely and effectively to access financial, health, education and government services. The results are also aligned with the Information Economics theory, which states that highly educated people have a larger capacity to lower the information gap by effectively using digital materials.

Moreover, the findings are consistent with Diffusion of Innovations Theory which suggests that the educated people are more likely to be early adopters as they have more awareness of and less uncertainty about technological innovations. Furthermore, the fact that digital awareness has increased gradually for all education categories shows that investments in education have a direct link to digital inclusion and socio-economic development.

Table 5: Chi-square Analysis

Test Results of Hypotheses (0.05)

Hypotheses Tested:

H 01: No correlation between education and awareness.

H 0 2: Occupation is not associated with Technology Preference.

H 03: There is no correlation between gender andTechnology usage.

Sr. No.	Hypothesis	Variables	Test Statistic	p-value	Decision ($\alpha = 0.05$)	Result Interpretation
1	H_{01}	Education × Digital Awareness	$\chi^2 = 18.45$	0.002	Reject H_0	Significant association exists
2	H_{02}	Occupation × Technology Preference	$\chi^2 = 12.32$	0.015	Reject H_0	Significant association exists
3	H_{03}	Gender × Technology usage	$\chi^2 = 3.21$	0.201	Fail to Reject H_0	No significant association

Note. Source: Author's analysis based on Primary data collected from survey

The Chi-square analysis reveals that there are statistically significant relationships between education with digital awareness ($\chi^2 = 18.45$, $p = 0.002$) and between occupation with technology preference ($\chi^2 = 12.32$, $p = 0.015$). Gender did not significantly predict technology use ($\chi^2 = 3.21$, $p = 0.201$), however.

Education and digital awareness are strongly correlated, which supports the main tenet of the Human Capital Theory, which states that a person's education increases his or her productive capacity and technological expertise. Likewise, there are differences across occupations in relation to increasing exposure to digital technologies, with service-sector jobs having this effect compared to traditional agricultural jobs.

The lack of a statistically significant relationship between gender and technology use could be due to the fact that the improvement of digital infrastructure and the increased availability of smartphones and Internet services may have diminished traditional gender gap. Such a result suggests that there is a stronger influence of the structural socio-economic measures rather than just the demographic measures. Thus, education and occupational skill development policies are more likely to lead to a more significant increase in digital inclusion than gender-specific policies.

Table 6: Independent Sample t-test

Variable	t-value	p-value	Result
Time to Access Healthcare	2.45	0.018	Significant Difference Reject H0

Note. Source: Author's analysis based on Primary data collected from survey

The independent sample t-test indicates that there is a statistically significant difference between the digital access time of male and female respondents ($t = 2.45$, $p = 0.018$).

Gender was not significantly related with technology adoption in the Chi-square analysis, however the significant difference in digital access time indicates that use of technology continues to be different between males and females. Variations in responsibilities in the household, work obligations, mobility and device ownership can be some of the reasons for such differences.

In the Capability Approach, the availability of technology is a crucial factor for access to opportunity and capabilities to the individual. Thus, policies should be developed beyond just ensuring the provision of digital infrastructure, but also focus on ensuring equal access to meaningful opportunities for the use of technology by gender.

Table 7: One-way ANOVA

Source of Variation	F-value	p-value	Result
Between Groups	6.78	0.001	Significant

Note. Source: Author's analysis based on Primary data collected from survey

The One-way ANOVA shows that there are statistically significant differences between the various educational groups ($F = 6.78$, $p = 0.001$).

This finding is a further confirmation of the significant effect of education on digital competence. Those with higher education show greater knowledge, confidence, and proficiency in using digital technologies. This relationship can be understood from the Human Capital Theory, which focuses on education as an investment to enhance productive efficiency and technological adaptation of individuals.

The results also corroborate with the literature on the Digital Divide, which shows that a key factor in digital participation is education. Hence, the need for investment in formal education and digital literacy programmes is still relevant in tackling digital inequalities in rural areas.

Table 8: Logistic Regression

Variable	Coefficient (β)	Standard Error	Wald Statistic	Odds Ratio (Exp β)
Constant	-1.45	0.52	7.78	—
Education	0.85	0.26	10.68	2.34
Age	0.03	0.015	4.00	1.03
Occupation	0.56	0.24	5.44	1.75
Gender	0.12	0.11	1.20	1.13

Note. Source: Author's analysis based on Primary data collected from survey

Table 9 : Goodness-of-Fit Statistics

Statistic	Value
-2 Log Likelihood	210.45

Cox & Snell R^2	0.32
Nagelkerke R^2	0.41
Model Chi-square	28.67
Model p-value	0.001
Classification Accuracy	72.5%

Note. Source: Author's analysis based on Primary data collected from survey

Education (β = 0.85), occupation (β = 0.56) and age (β = 0.03) are positive predictors of digital awareness, while gender is not significantly associated with digital awareness after adjusting for socio-economic factors. The model is a good model (Nagelkerke R^2 = 0.41) and the accuracy of classification was 72.5%.

The results of the regression analysis show that education is the most significant factor in digital awareness. Human Capital Theory states that education improves the capacity of the individual to receive and process information, and thus allows for the use of technology. The positive is also attributable to occupational exposure as those who work in a service sector are more likely to be exposed to digital platforms. There is a slight positive correlation with age to show the value of wealth derived from experience and economic activity.

After adjusting for the socio-economic variables, the insignificance of gender indicates that gender differences observed are likely due to the socio-economic variables rather than gender itself. The results confirm the fact that socio-economic inequalities are the main obstacles to digital inclusion.

SEM / Path Coefficient Table

Table 10: Path Analysis Results

Path Relationship	Coefficient	p-value	Result
Education → Awareness	0.62	0.001	Significant
Awareness → Healthcare Utilization	0.55	0.003	Significant
Distance → Utilization	-0.48	0.005	Significant
Utilization → Financial Burden	0.60	0.002	Significant
Traditional Medicine → Utilization	-0.35	0.020	Significant

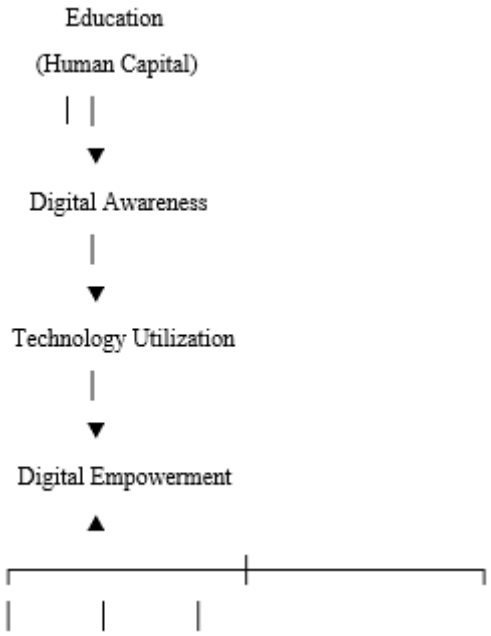
Note. Source: Author's analysis based on Primary data collected from survey

The path analysis showed that education had the greatest effect on digital awareness (β = 0.62, $p < 0.001$) and digital awareness had the greatest effect on technology utilization (β = 0.55, p = 0.003). Better technology usage goes hand in hand with digital empowerment.

The structural relationships support the integrated economic framework for this study in an empirical way. In education, the principal purpose is to invest in human capital to enhance digital awareness. Enhanced awareness can help to reduce information asymmetry, eliminate transaction costs in accessing services and promote technology uptake. In the end, technology usage is a means of increasing digital empowerment and access to education, healthcare, financial services, markets, and government programmes.

These findings provide a merger of Human Capital Theory, Information Economics, Transaction Cost Economics and the Capability Approach in one analytical framework. They also support the Diffusion of Innovations Theory and the Technology Acceptance Model, as they show how socio-economic capabilities influence behavioural acceptance of technology.

Conceptual Framework



(Direct Effects)

- **Education = Human Capital TheoryHuman Capital Theory = Education**

  or information economics: Digital Awareness
- **Theory of Transaction Cost Economics → Theory of Technology Utilization**
- **The kind of ability necessary to empower oneself and others through information and communications technology (ICTs).**
- **TAM & DOI → Overall pathway of awareness to utilization.**

Conclusion

The study showed that the most powerful socio-economic factor affecting digital awareness and technology adoption among rural households is education, followed by occupation and age, and that gender has a limited effect beyond the socio-economic factors. The results indicate that investments in human capital have a significant impact on achieving digital literacy, adoption of technologies, and digital empowerment.

The study also reveals the role of digital awareness as a productive asset from an economic perspective: it minimizes information asymmetry and transaction costs, and increases the capability of individuals to access the digital economy. The empirical evidence confirms the integrated approach: education increases the human capital, digital awareness facilitates the adoption of technology, and the adoption of technology helps build digital

empowerment and inclusive rural development. The results indicate that a combination of policies to increase educational standards, digital skills, affordable digital infrastructure and digital training for specific occupations can have a major impact on digital inclusion and help to mitigate socio-economic disparities in rural areas. This integrated approach contributes to the existing literature by connecting classical economic theories with the new frameworks on technology adoption, thus achieving a comprehensive understanding of digital transformation in the rural economies.

The Implications, Limitations, and Future Research Directions should also be updated to reflect this shift in the study's focus from the technology adoption to the economics perspective. They should be based on the integrated theoretical framework made up of the Human Capital Theory, Information Economics, Transaction Cost Economics and the Capability Approach, but keeping alongside them the two theories TAM and Diffusion of Innovations (DOI).

Implications of the study.

This study's findings have implications for theory, practice and policy on how to promote inclusive rural development and digital inclusion. Theoretically, the study combines the Technology Acceptance Model (TAM) (Davis, 1989) and the Diffusion of Innovations Theory (DT) (Rogers, 2003) with the Human Capital Theory (Becker, 1964), Information Economics (Akerlof, 1970) and the Transaction Cost Economics (Coase, 1937) and the Capability Approach (Sen, 1999). TAM and DOI builds on the concept of behavioural acceptance and diffusion of digital technologies, whereas the present study shows how education and occupation are investments in human capital that contributes to digital awareness, decrease information asymmetry, decrease transaction costs and ultimately promotes technology adoption and digital empowerment. The empirical evidence is thus adding to the current body of digital economics literature and offers a synthesis of the socio-economic characteristics, digital awareness, and digital technology adoption and digital empowerment of rural households.

On a practical level, the study emphasizes the importance of education as the most important factor of digital awareness, followed by occupation and age, with gender being statistically insignificant once socio-economic factors are controlled for. The results suggest that measures of human capital investment, such as formal education, vocational training, and lifelong digital literacy programmes, are likely to yield higher returns in terms of digital inclusion than ones solely based on demographic characteristics. It is important that educational institutions, community learning centres, agricultural extension agencies and local self-governance institutions work together to enhance the digital skills of the rural population. More individuals would be able to engage effectively in the digital financial service sector, online markets, telemedicine, e-learning and e-governance if digital literacy were integrated in school curricula, vocational education, farmer training programmes and adult education programmes.

The policy implications are also important. The results indicate a need to develop a policy framework to address the digital divide that focuses on building human capital, digital infrastructure, and institutional support. Governments need to focus on providing rural communities with affordable broadband connectivity, reliable mobile networks, smart affordable devices and available public digital infrastructure. Digital resource centres, multi-lingual digital platforms and community based training programs would decrease information asymmetries and transactions costs for accessing government services, health and agricultural markets, and financial services. These interventions align with the vision of India's Digital India Programme, financial inclusion programmes and the United Nations Sustainable Development Goals (SDG), especially SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), and SDG 10 (Reduced Inequalities). These policies can boost household productivity, economic inclusion and inclusive rural development by strengthening the capacities of households in the digital domain.

Limitations

However, there are a number of limitations to the present study which should be taken into consideration when interpreting the findings of this study. First, the study is confined to a small sample of rural households from a particular geographical area, thus results from this study may not be generalisable elsewhere in socio-economic and cultural settings. A larger region or national survey would have had more external validity.

Secondly, the study used a Cross Sectional Research Design in a one time sampling, which also records the perception of the respondents. The study is thus unable to pinpoint causal effects, or determine the impacts of digital infrastructure, policy, or socio-economic development on digital awareness and digital technology use.

Third, the study has focused on key socio-economic determinants of gender empowerment (education, occupation, age, gender) but other socio-economic determinants which are relevant to everyday life online, such as household income, internet affordability, quality of digital infrastructure, digital trust, cybersecurity concerns, institutional support and behavioural factors, have not been included in the empirical model. These variables could be added to enhance the explanatory power of the analysis.

Fourth, all items measuring digital awareness and technology adoption are self-reported and could be subject to recall and social desirability biases. Objective indicators of digital skills and real use of technology might offer more solid evidence.

Last, the study considers technology adoption as a unified construct, and does not differentiate between different digital technologies, including digital financial services, e-commerce, digital agriculture, telemedicine, online education, artificial intelligence or e-governance platforms. Because these dimensions may vary by technology, future studies should consider them in isolation.

Future Research Directions

The present study could help with several avenues for future research. Future research should adopt a longitudinal approach to investigate the changes in digital awareness, technology adoption and digital empowerment over time, as a result of educational enhancements, technological advancements, and government policies. These studies would give more solid evidence of the causal relationship between the formation of human capital and digital inclusion.

Cross-district, cross-state, and cross-country comparative studies would give insight on the disparities between regions in terms of digital adoption and help researchers identify socio-economic conditions that drive digital inclusion in their specific region. Comparisons between rural and urban households would also offer insight into the differences in digital skills and the use of technology.

More complicated models of digital adoption should be built by adding other economic and behavioural factors, including household income, wealth, affordability of accessing the internet, ownership of a smartphone, digital self-efficacy, digital trust, social influence, institutional quality, government support, and awareness of cybersecurity. The theoretical explanation of digital behaviour could be further reinforced by integrating the Human Capital, Information Economics, Capability Approach, Digital Divide Theory, UTAUT and the Technology–Organization–Environment (TOE) Framework.

In terms of methodology, future studies should use the Structural Equation Modelling (SEM), multilevel modelling, mediation and moderation analysis, panel data econometrics and machine learning techniques to explore the complex relationships between socio-economic characteristics, digital awareness, technology adoption, and digital empowerment. These strategies would help researchers to better determine direct, indirect, and contextual effects.

Future studies should also explore the adoption and socio-economic implications of other key advancements in digital technologies, such as AI, blockchain, the Internet of Things (IoT), digital agriculture platforms, fintech applications, and digital public infrastructure, on rural livelihoods, agricultural productivity, financial inclusion and sustainable development.

Finally, qualitative and mixed-method studies (interviews, focus group discussions, participative rural appraisal, case studies) would offer deeper insights into the behavioural, institutional and cultural factors that affect the adoption of technology. This evidence would help inform policy development for more inclusive, context specific digital strategies to ensure that the needs of digitally excluded and marginalised rural communities are met and contribute to equitable and sustainable economic development.

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