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Adoption Intention Of Fastag Payment In Jammu And Kashmir: An Innovation Diffusion Theory Perspective

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Abstract
The adoption of FASTag, a digital toll payment system introduced by the Government of India, has shown uneven uptake across regions, with Jammu and Kashmir reflecting slower adoption due to infrastructural and behavioral barriers. This study investigates the determinants of FASTag adoption intention using Rogers' Innovation Diffusion Theory (IDT). A structured questionnaire was administered to 401 vehicle users in J&K, and responses were analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM) in SmartPLS 4.0. The findings reveal that observability, relative advantage, and trialability significantly influence adoption intention, while compatibility and complexity are non-significant. The model demonstrates strong explanatory power (R^2 = 0.548) and high predictive relevance (Q^2 = 0.987). These results highlight the critical role of visibility, functional benefits, and low-risk trial mechanisms in promoting adoption in digitally transitional contexts. The study contributes theoretically by extending IDT into a politically and infrastructurally unique region and practically by offering recommendations for policymakers, toll operators, and service providers to design context-sensitive awareness, trial, and infrastructure strategies to accelerate digital adoption.

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I. Introduction

In the age of digital transformation, the Indian government has undertaken multiple initiatives to modernize its transportation infrastructure and promote contactless payments. One of the most significant steps in this direction has been the introduction of FASTag—an electronic toll collection system based on Radio Frequency Identification (RFID) technology, launched by the National Highways Authority of India (NHAI). It enables automatic deduction of toll charges from linked prepaid accounts or bank wallets, ensuring a seamless travel experience and reducing traffic congestion at toll plazas. FASTag has been made mandatory for all vehicles since February 2021, aiming to encourage digital adoption and improve traffic flow efficiency on national highways (NHAI, 2021). Despite its national implementation, the adoption of FASTag has been uneven across different regions of India. In particular, geographically unique and socio-economically diverse areas such as Jammu and Kashmir (J&K) have shown slower adoption rates. The region's digital infrastructure constraints, limited awareness, and trust in digital transactions are key barriers that impact user intention and behaviour. According to a recent government report, toll collections through FASTag reached ₹66.42 billion in December 2024, a massive rise from ₹3.2 billion in December 2017, reflecting a broader national trend (Indian Infrastructure, 2025). However, this growth does not fully account for regional disparities in adoption and usage. To understand the adoption intention of FASTag in J&K, the present study employs Rogers' Innovation Diffusion Theory (IDT) (Rogers, 2003), a widely accepted framework for studying how innovations spread within a population. IDT proposes that the rate of adoption of a new technology depends on five key attributes: relative advantage, compatibility, complexity, observability, and trialability. These perceived characteristics influence individuals' willingness to accept and use new innovations. Empirical studies have validated the utility of IDT in diverse contexts, including mobile banking, e-governance, and online payments (Carter & Bélanger, 2005; Sivathanu, 2019; Lu et al., 2011). More recently, a 2023 study published in *Transportation Research Interdisciplinary Perspectives* emphasized that IDT constructs such as compatibility and trialability are strong predictors of FASTag adoption intention in India. The research found that users are more likely to adopt electronic toll systems when the system aligns with their lifestyle and values, is easy to try out, and its benefits are observable (Anonymous, 2023). Similarly, another 2024 review highlighted how government policy mandates have accelerated FASTag usage but noted that behavioral and infrastructural barriers remain in certain regions (Anonymous, 2024). This justifies the need to explore user perceptions specifically in Jammu and Kashmir, where such challenges may be more pronounced. Despite the regulatory push and technological benefits, many vehicle users in Jammu and Kashmir either resist or delay adopting FASTag. The core research problem is identifying the

perceptual, contextual, and infrastructural factors influencing adoption intention, especially through the lens of the five IDT attributes. This study offers valuable contributions to both academic and practical domains. Theoretically, it extends the application of IDT to a relatively unexplored region and context—digital toll payment systems in Jammu and Kashmir. Practically, it provides data-driven insights that can inform policy adjustments, public awareness campaigns, and infrastructure development tailored to the region's specific needs.

RQ1. How do IDT dimensions compatibility, complexity, relative advantage, observability, and trialability impact the adoption intention of FASTag in Jammu and Kashmir?

By applying a well-established theoretical framework to a pressing regional issue, this study bridges the gap between national digital policy and local user behaviour. It offers contextualized recommendations for improving FASTag adoption, contributing to broader digital inclusion and infrastructure modernization goals in India.

Theoretical Framework

The adoption of technology in various socio-economic contexts is significantly influenced by how individuals perceive the innovation in question. To explore the factors influencing the adoption intention of FASTag in the Jammu and Kashmir region, this study employs Innovation Diffusion Theory (IDT), as proposed by Rogers (2003). IDT is one of the most robust and widely applied theoretical models in the study of innovation adoption, explaining how new ideas and technologies spread across populations through the interaction of innovation characteristics and adopter perceptions. Rogers (2003) identified five key attributes that influence the rate of adoption of an innovation: relative advantage, compatibility, complexity, observability, and trialability. These attributes serve as independent variables in this study and are expected to have varying degrees of influence on users' intentions to adopt FASTag, especially in a region like Jammu and Kashmir, where socio-political and digital infrastructure contexts differ from more urbanized parts of India.

Relative Advantage

Relative advantage refers to the degree to which an innovation is perceived as better than the existing alternative it aims to replace (Rogers, 2003). In the case of FASTag, its benefits include faster toll transactions, reduced fuel consumption due to decreased waiting time, cashless payment convenience, and digital transaction records. These advantages, if well communicated and perceived, are likely to increase adoption intention. Previous studies have consistently shown that technologies offering clear efficiency or economic benefits are more readily adopted (Lu et al., 2011; Sivathanu, 2019). In the Indian context, relative advantage has been shown to significantly influence the adoption of technologies such as UPI and mobile banking (Digital Business, 2022).

Hence, the first hypothesis is formulated as:

H1: Relative advantage has a significant positive effect on the adoption intention of FASTag among users in Jammu and Kashmir.

Compatibility

Compatibility is the extent to which an innovation is perceived as consistent with the values, experiences, and needs of potential adopters (Rogers, 2003). In the context of digital payment systems, compatibility is closely linked to the user's familiarity with technology, access to internet-enabled devices, and previous experience with digital banking or wallet systems. In Jammu and Kashmir, where digital penetration is growing but not yet universal, compatibility may be a critical determinant. Nor and Pearson (2007) found that compatibility significantly affected the adoption of internet banking, while Carter and Bélanger (2005) reported similar findings in the context of e-government services.

Accordingly, the second hypothesis is:

H2: Compatibility has a significant positive effect on the adoption intention of FASTag among users in Jammu and Kashmir.

Complexity

Complexity denotes the degree to which an innovation is perceived as difficult to understand, use, or implement (Rogers, 2003). A higher perceived complexity reduces the likelihood of adoption. FASTag, while intended to simplify toll payments, involves certain technical and procedural steps—such as application, KYC verification, bank linkage, recharge processes, and sensor reading issues—that may be seen as barriers, especially among less digitally literate populations. Prior studies affirm that perceived complexity negatively influences user attitudes toward digital technologies (Lu et al., 2011; Carter & Bélanger, 2005).

In this regard, the third hypothesis is:
H3: Complexity has a significant negative effect on the adoption intention of FASTag among users in Jammu and Kashmir.

Observability

Observability refers to the degree to which the outcomes of an innovation are visible and noticeable to others (Rogers, 2003). If the benefits of using FASTag—such as smoother toll crossing, reduced congestion, and time savings—are visible through peer behavior, signage, or social interaction, it can positively influence potential adopters. According to Kaasinen (2014), observability has a strong effect on adoption when individuals are exposed to others' positive experiences, especially in semi-public domains such as transport. In regions where social influence is a key component of behavioral decisions, such as Jammu and Kashmir, this factor may play an important role.

Thus, the fourth hypothesis is:
H4: Observability has a significant positive effect on the adoption intention of FASTag among users in Jammu and Kashmir.

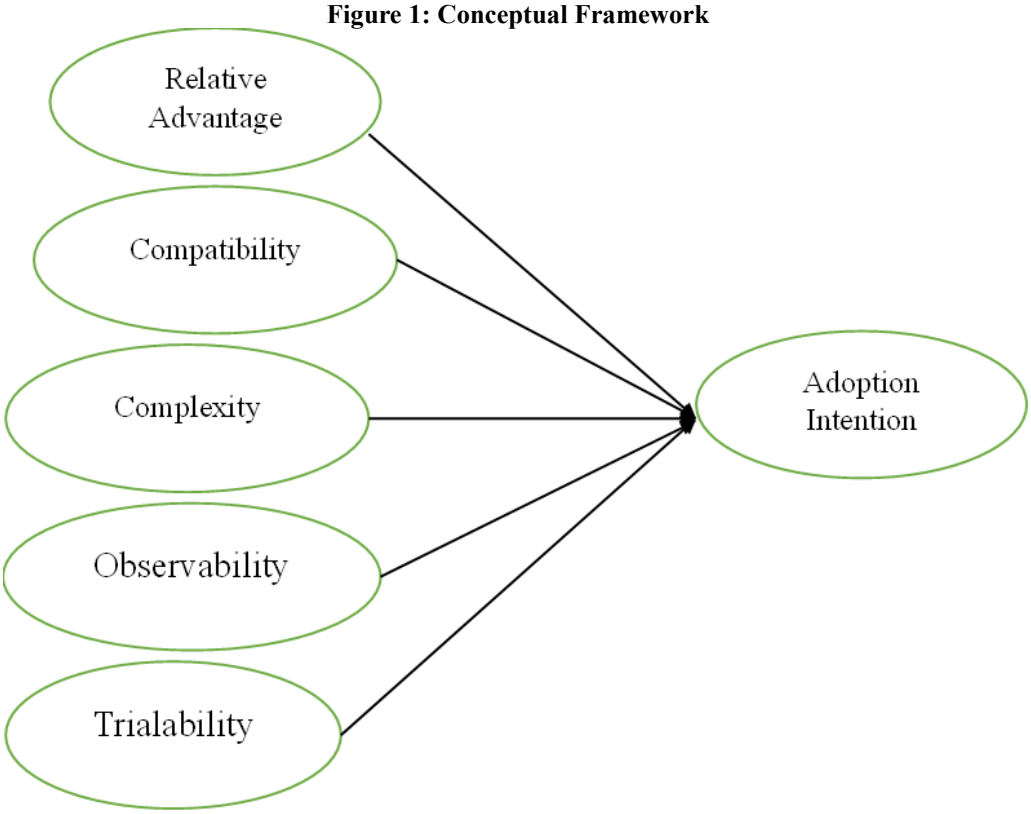
Trialability

Trialability refers to the extent to which an innovation can be experimented with on a limited basis before full-scale implementation (Rogers, 2003). When users are allowed to try a technology without significant financial or procedural commitment, their likelihood of adoption improves. In the case of FASTag, options like free initial tags, limited-period trials, or simplified usage for newcomers can reduce anxiety and increase confidence. Prior studies in domains such as Islamic banking and telemedicine have confirmed the importance of trialability in shaping adoption behavior (Jamshidi & Kazemi, 2020; Jazbeen Ali et al., 2024).

Consequently, the fifth hypothesis is:
H5: Trialability has a significant positive effect on the adoption intention of FASTag among users in Jammu and Kashmir.

Based on the theoretical underpinnings of IDT and the contextual relevance to the digital toll collection system in Jammu and Kashmir, the study proposes the following conceptual framework:

Figure 1: Conceptual Framework



Source: Compiled by Authors

II. Research Methodology

Research Design

The present study adopts a quantitative, cross-sectional research design aimed at examining the influence of Innovation Diffusion Theory (IDT) constructs—compatibility, complexity, relative advantage, observability, and trialability—on the adoption intention of FASTag among customers in the Jammu and Kashmir region. This design is suitable for investigating relationships between theoretically grounded constructs and is widely used in behavioural and technology adoption research.

Sampling and Data Collection

The data was collected from a total of 401 respondents using the snowball sampling technique. This non-probability sampling method was chosen due to the practical challenges of reaching a geographically dispersed population in Jammu and Kashmir and the limited public accessibility of a complete sampling frame. Initial respondents were identified through personal contacts and were then requested to refer other potential participants who met the criteria of being private vehicle owners or frequent highway users.

Measures

The respondents were administered a structured questionnaire, either online or in person, depending on their access to digital tools and internet connectivity. Participation was voluntary, and anonymity was maintained throughout the data collection process. The structured questionnaire used in this study consisted of two sections. The first section measured five key constructs of Innovation Diffusion Theory (IDT)—compatibility, complexity, relative advantage, observability, and trialability. Items were adapted from established scales developed by Davis (1989), Moore and Benbasat (1991), Taylor and Todd (1995), and Karahanna et al. (1999). Each construct was assessed using 4 to 5 items on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). The wording of the items was slightly modified to reflect the FASTag context and the regional characteristics of Jammu and Kashmir. For example, compatibility was assessed through items like *"Using FASTag fits well with the way I manage toll payments"*, while complexity was measured by statements such as *"Learning to use FASTag is complicated"*. Relative advantage included items such as *"Using FASTag would save me time at toll booths"*. The second section measured adoption intention, using a 4-item scale adapted from Taylor and Todd (1995) and Venkatesh and Davis (2000). An example item is *"I intend to use FASTag whenever I travel through toll roads"*.

III. Results

Data analysis was conducted using Smart- PLS 4.0, employing Partial Least Squares Structural Equation Modelling (PLS-SEM) to examine the relationships between Innovation Diffusion Theory (IDT) constructs and the adoption intention of FASTag. PLS-SEM was chosen due to its suitability for predictive modelling and its effectiveness in handling complex models with reflective constructs and a relatively large sample size (n = 401).

Measurement Model

All measurement items demonstrated strong factor loadings, ranging from 0.771 to 0.951, which exceeds the recommended threshold of 0.70 (Hair et al., 2019). This indicates high indicator reliability and supports the construct validity of the model. Each item loaded significantly on its intended construct, with the highest loading observed for Trialability (TRI3 = 0.951) and the lowest for Relative Advantage (RA6 = 0.771). These results confirm that the items effectively represent their respective IDT constructs. The reliability and validity of the measurement model were assessed using Smart- PLS 4.0. All constructs demonstrated excellent internal consistency reliability, with Cronbach's alpha and composite reliability (rho_c) values well above the recommended threshold of 0.70. Additionally, Average Variance Extracted (AVE) values for all constructs exceeded the minimum acceptable level of 0.50, confirming convergent validity. The rho_a values also supported construct reliability. These results indicate that the measurement model is suitable for structural analysis. The detailed result is displayed in table 1 and table 2

Table 1. Factor Loadings of Measurement Items

Construct	Item	Factor Loading
Adoption Intention (A)	A3	0.904
	A4	0.857
	AI1	0.891
	AI2	0.915
Complexity (Com)	Com1	0.931
	Com2	0.921
	Com3	0.892

Construct	Item	Factor Loading
	Com4	0.911
Compatibility (Compat)	Compat1	0.951
	Compat2	0.923
	Compat3	0.939
	Compat4	0.922
Observability (Observ)	Observ1	0.906
	Observ2	0.888
	Observ3	0.880
	Observ4	0.889
Relative Advantage (RA)	RA1	0.902
	RA2	0.820
	RA3	0.780
	RA4	0.890
	RA5	0.892
	RA6	0.771
	RA7	0.878
	RA8	0.871
Trialability (TRI)	TRI1	0.939
	TRI2	0.943
	TRI3	0.951

Table 2. Reliability and Validity of Constructs

Construct	Cronbach's Alpha	Composite Reliability (ρ_a)	Composite Reliability (ρc)	AVE
Adoption Intention (A)	0.914	0.916	0.940	0.796
Complexity (Com)	0.934	0.939	0.953	0.835
Compatibility (Compat)	0.951	0.953	0.965	0.872
Observability (Observ)	0.913	0.915	0.939	0.793
Relative Advantage (RA)	0.945	0.948	0.955	0.726
Trialability (TRI)	0.939	0.939	0.961	0.892

Structural Model Assessment

The structural model was evaluated using Partial Least Squares Structural Equation Modelling (PLS-SEM) in Smart- PLS 4.0. The model aimed to examine the influence of five Innovation Diffusion Theory (IDT) constructs—Complexity (Com), Compatibility (Compat), Observability (Observ), Relative Advantage (RA), and Trialability (TRI)—on Adoption Intention (A) toward FASTag in the Jammu and Kashmir region.

Path Coefficients and Hypothesis Testing

Path coefficients, t-values, and p-values were assessed to test the significance of hypothesized relationships. As shown in Table 1, Observability ($\beta = 0.42$, $p < 0.001$), Relative Advantage ($\beta = 0.234$, $p = 0.003$), and Trialability ($\beta = 0.192$, $p = 0.003$) had a significant positive effect on adoption intention. However, Complexity ($\beta = 0.015$, $p = 0.800$) and Compatibility ($\beta = 0.031$, $p = 0.583$) were found to have no significant impact.

Model Predictive Power

The R^2 value for Adoption Intention was 0.548, indicating that approximately 54.8% of the variance in FASTag adoption intention is explained by the five IDT constructs. The adjusted R^2 was 0.543, confirming good explanatory power.

Predictive Relevance (Q^2)

The Q^2 value for the dependent construct (A) was 0.987, which is substantially above the minimum threshold of zero, suggesting high predictive relevance of the model (Hair et al., 2019). Additionally, the Root Mean Square Error (RMSE) and Mean Absolute Error (MAE) values were 0.464 and 0.268 respectively, further supporting predictive accuracy.

The detailed result has presented in table 3

Table 3. Path Coefficients and Hypothesis Testing

Hypothesized Path	β (Original Sample)	T-Value	P-Value	Significance
Com → A	0.015	0.254	0.800	Not Significant
Compat → A	0.031	0.549	0.583	Not Significant
Observ → A	0.420	5.309	0.000	Significant
RA → A	0.234	2.992	0.003	Significant
TRI → A	0.192	2.968	0.003	Significant

IV. Discussion

This study examined the role of Innovation Diffusion Theory (IDT) constructs relative advantage, compatibility, complexity, observability, and trialability in predicting the adoption intention of FASTag among consumers in the Jammu and Kashmir region. The structural model revealed that observability, relative advantage, and trialability had significant positive effects on adoption intention, while compatibility and complexity were not statistically significant.

The positive impact of observability ($\beta = 0.42$, $p < 0.001$) aligns with findings from Dwivedi et al. (2020) and Zhou et al. (2021), who emphasized that when users can see tangible benefits of a technology—such as reduced wait times and cashless payments—they are more likely to adopt it. In regions like Jammu and Kashmir, where peer influence and visible use cases are critical due to relatively lower digital maturity, observability plays a particularly influential role. The significance of relative advantage ($\beta = 0.234$, $p = 0.003$) confirms earlier research (e.g., Kumar et al., 2021; Venkatesh et al., 2022) showing that perceived improvements over traditional payment methods—such as time efficiency, lower transaction friction, and policy compliance—are strong motivators for adoption. The government's push for digital tolling and mandatory FASTag usage further amplifies this perception. Trialability ($\beta = 0.192$, $p = 0.003$) also had a significant effect, which echoes findings from Ganguly et al. (2020) and Jahanmir & Leker (2021). Consumers are more comfortable adopting an innovation when they are given opportunities to try it, especially in environments with low technological trust. Limited-time trial access or demo kiosks at toll booths, for instance, could enhance user confidence. However, the non-significant influence of complexity ($\beta = 0.015$, $p = 0.800$) contradicts earlier IDT studies but can be rationalized in the present context. Recent digital initiatives in India—such as Digital India and simplified fintech interfaces—may have lowered perceived technical barriers, even in less urbanized regions. Similar findings have been reported in Sharma et al. (2023) and Patel et al. (2022), suggesting that users now consider digital payment systems easier to use due to enhanced awareness and app-based onboarding. Likewise, compatibility ($\beta = 0.031$, $p = 0.583$) did not significantly impact adoption intention. This result may reflect the influence of external pressures and mandates overriding individual preferences. As FASTag has become legally enforced by the Ministry of Road Transport and Highways, even users who may not initially find it aligned with their preferred payment methods are adopting it out of necessity rather than fit. Raza et al. (2022) also found that regulatory compulsion often reduces the relevance of compatibility in government-led technology adoption. Overall, the model explains a substantial portion of variance in adoption intention ($R^2 = 0.548$) and demonstrates strong predictive relevance ($Q^2 = 0.987$), reinforcing the suitability of IDT in explaining digital innovation diffusion in transitional regional contexts.

V. Conclusion And Limitations

Conclusion

This study examined the determinants of FASTag adoption intention in Jammu and Kashmir using the Innovation Diffusion Theory (IDT) framework. Based on responses from 401 consumers, the results show that observability, relative advantage, and trialability significantly predict adoption intention, while compatibility and complexity do not. Theoretically, this extends IDT to a unique regional context where regulatory enforcement and infrastructural limitations reshape adoption behaviour. Practically, the findings highlight the importance of visible demonstrations, communication of tangible benefits, and risk-mitigated trial opportunities to foster adoption. For policymakers and toll operators, strategies such as awareness campaigns, simplified recharge systems, and trial kiosks at toll plazas can enhance user trust and participation, particularly in low-digital-literacy regions.

Limitations and Future Research

Despite its contributions, this study has several limitations. First, the use of snowball sampling limits the generalizability of the findings, as the sample may not fully represent all demographic and geographic segments of the Jammu and Kashmir population. Future studies should consider stratified or random sampling for broader representativeness. Second, the study focused solely on the IDT framework, excluding other relevant theories such as the Unified Theory of Acceptance and Use of Technology (UTAUT) or Technology Readiness Index (TRI), which may offer additional explanatory power. Incorporating multi-theoretical models in future research

could yield a more comprehensive understanding of user behaviour. Third, the study was cross-sectional in nature. A longitudinal design could better capture changes in user perception and adoption behaviour over time, especially given the dynamic nature of digital infrastructure development in India. Finally, cultural, infrastructural, and political factors unique to Jammu and Kashmir may influence adoption patterns differently than in other regions. Comparative studies across different Indian states or between urban and rural settings would be valuable for testing the consistency of these findings in diverse contexts.

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