



Leveraging IoT Synergy: An Industry-Led Empirical Study of Collaboration in Nepal

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Abstract

The Internet of Things (IoT) is increasingly recognized as a key driver of digital transformation; however, its adoption in developing economies such as Nepal remains fragmented and context-dependent. While prior studies have primarily focused on infrastructural limitations and policy gaps, limited empirical attention has been given to the role of collaboration in enabling IoT adoption. This study examines how industry-led collaboration influences IoT adoption in Nepal by introducing the concept of IoT synergy, defined as the interaction among firms, institutions, and knowledge networks that collectively shape adoption outcomes.

A mixed-method research design was employed, combining quantitative data collected through structured questionnaires from IoT-related firms and professionals with qualitative insights from open-ended responses. The study analyzes five key dimensions: technological readiness, economic feasibility, policy support, market awareness, and collaborative synergy. Descriptive statistics and reliability analysis were conducted using SPSS, while qualitative data were thematically analyzed to complement the quantitative findings.

The results indicate that collaboration-oriented factors such as inter-firm coordination, academia industry linkage, and knowledge sharing significantly enhance IoT adoption readiness. Technological readiness also demonstrates strong influence, whereas policy and regulatory support remain comparatively weak. The findings highlight that IoT adoption in Nepal is not solely driven by technological or financial capacity, but is strongly dependent on the strength of collaborative ecosystems.

This study contributes to the literature by positioning collaboration as a critical enabler of IoT adoption in developing contexts. It further provides practical implications for policymakers and industry stakeholders to foster integrated, network-driven innovation ecosystems for scalable IoT implementation in Nepal.

Keywords: Internet of Things (IoT), Collaboration, IoT Synergy, Technology Adoption, Nepal, Industry Perspective, Digital Transformation, Empirical Study, Developing Economies

1. Introduction

1.1. Background

The Internet of Things (IoT) has emerged as a transformative technological paradigm that enables interconnected devices to collect, exchange, and process data in real time. Globally, IoT is driving innovation across sectors such as manufacturing, healthcare, agriculture, and urban infrastructure, contributing significantly to the advancement of digital economies (Atzori *et al.*, 2010; Porter & Heppelmann, 2014) ^[1, 9]. In developing countries, IoT holds particular promise for addressing structural challenges through smart and data-driven solutions.

In Nepal, the adoption of IoT is still at a nascent stage but gradually gaining momentum, especially within urban and semi-urban regions. The growth of ICT infrastructure, increased internet penetration, and the emergence of technology startups have created a favorable environment for IoT experimentation. However, the ecosystem remains fragmented, with limited integration among industry, academia, and government institutions. As a result, IoT initiatives are often isolated and lack scalability.

1.2. Motivation

While existing studies on IoT adoption in Nepal primarily emphasize barriers such as inadequate infrastructure, high implementation costs, and regulatory uncertainties, there is a growing need to explore enabling factors that can accelerate adoption. One such factor is collaboration among ecosystem stakeholders, including private firms, educational institutions, government bodies, and innovation hubs.

In many developing contexts, collaborative ecosystems play a crucial role in facilitating knowledge exchange, reducing uncertainty, and enabling resource sharing (Etzkowitz & Leydesdorff, 2000) [3]. Understanding how such collaborative mechanisms function within Nepal's IoT landscape can provide deeper insights into adoption dynamics beyond traditional technological and economic perspectives.

1.3. Problem Statement

Despite increasing interest in IoT, Nepal faces challenges in translating potential into widespread adoption. Existing research tends to focus on isolated determinants such as infrastructure readiness or policy constraints, often overlooking the systemic interactions among stakeholders. The lack of empirical studies examining collaborative synergy as a determinant of IoT adoption creates a significant research gap.

Without a clear understanding of how collaboration influences IoT adoption, policymakers and industry actors may fail to design effective strategies that foster integrated and sustainable innovation ecosystems.

1.4. Objectives

The primary objective of this study is to examine the role of industry-led collaboration in influencing IoT adoption in Nepal. The specific objectives are:

To identify key factors influencing IoT adoption in Nepal

- To analyze the role of collaborative synergy among industry stakeholders
- To evaluate the relative importance of technological, economic, policy, and collaborative factors
- To provide practical recommendations for strengthening IoT adoption through ecosystem-based approaches

1.5. Contribution of the Study

This study makes several important contributions to both theory and practice. First, it extends the existing body of knowledge on technology adoption by introducing the concept of IoT synergy in the context of a developing economy. Second, it provides empirical evidence on the role of collaboration as a critical enabler of IoT adoption, which has been relatively underexplored in prior studies. Third, the study offers actionable insights for policymakers, industry stakeholders, and innovation-support institutions to foster a more integrated and collaborative IoT ecosystem in Nepal. By shifting the focus from isolated barriers to systemic enablers, this research contributes to a more holistic understanding of IoT adoption dynamics in emerging economies.

2. Literature Review

2.1. IoT Adoption in Developing Economies

The adoption of the Internet of Things (IoT) has been widely studied in both developed and developing contexts, with

significant emphasis on its potential to enhance efficiency, productivity, and innovation. In developing economies, IoT adoption is often constrained by infrastructural limitations, high implementation costs, and limited technical expertise (Lee & Lee, 2015; Madakam *et al.*, 2015) [7, 8]. However, these contexts also present unique opportunities where IoT can address systemic challenges such as resource inefficiency and service delivery gaps.

Studies suggest that IoT adoption is influenced by multiple factors, including technological readiness, financial capacity, regulatory environment, and organizational capability (Kumar *et al.*, 2019) [6]. In South Asian contexts, including Nepal, adoption remains uneven, often concentrated in urban centers with relatively better ICT infrastructure. This indicates that beyond technological availability, ecosystem-level dynamics play a critical role in shaping adoption outcomes.

2.2. Theoretical Foundations of Technology Adoption

Technology adoption research has been guided by several theoretical models, including the Technology Acceptance Model (TAM), Diffusion of Innovation (DOI), and the Technology–Organization–Environment (TOE) framework. TAM emphasizes perceived usefulness and ease of use as key determinants of technology adoption (Davis, 1989) [2]. DOI focuses on how innovations spread over time within a social system (Rogers, 2003) [11], while the TOE framework highlights the interaction of technological, organizational, and environmental factors in influencing adoption decisions (Tornatzky & Fleischer, 1990) [12].

Among these, the TOE framework is particularly relevant for IoT adoption as it accommodates multiple dimensions beyond individual perception. It allows for the inclusion of external factors such as regulatory policies and market conditions, which are critical in developing economies. However, existing models often treat these factors independently and do not explicitly account for collaborative interactions among stakeholders.

2.3. Role of Collaboration in Technology Adoption

Collaboration has emerged as a key enabler of innovation and technology diffusion, particularly in complex and resource-constrained environments. The concept of the Triple Helix model highlights the interaction between academia, industry, and government as a driver of innovation ecosystems (Etzkowitz & Leydesdorff, 2000) [3]. In such ecosystems, knowledge sharing, joint problem-solving, and co-creation of solutions enhance the capacity for technology adoption.

Empirical studies indicate that collaboration reduces uncertainty, facilitates access to resources, and accelerates learning processes (Powell *et al.*, 1996) [10]. In the context of IoT, collaboration is especially important due to the interdisciplinary nature of the technology, which requires integration of hardware, software, data analytics, and domain-specific expertise. Despite its importance, collaboration is often underdeveloped in emerging economies, leading to fragmented innovation efforts.

2.4. IoT Ecosystem and Synergy Concept

The concept of IoT ecosystems refers to the network of interconnected stakeholders, including technology providers, users, regulators, and support institutions, that collectively influence IoT deployment (Gubbi *et al.*, 2013) [4]. Within this ecosystem, synergy arises when collaborative interactions

create outcomes greater than the sum of individual efforts. IoT synergy can be understood as the alignment and integration of resources, knowledge, and capabilities across stakeholders to enable effective adoption and scaling of IoT solutions. This includes activities such as joint research initiatives, public–private partnerships, industry networking, and knowledge-sharing platforms. In developing contexts like Nepal, where resources are limited, such synergy becomes critical for overcoming structural constraints.

2.5. Research Gap

Although existing literature provides substantial insights into the determinants of IoT adoption, there is a notable gap in understanding the role of collaborative synergy in shaping adoption outcomes, particularly in developing countries. Most studies focus on individual factors such as infrastructure, cost, or policy, without examining how interactions among stakeholder’s influence adoption. In the context of Nepal, empirical research on IoT adoption remains limited, and studies that integrate collaboration as a core analytical dimension are scarce. This study addresses this gap by positioning collaboration not as a peripheral factor, but as a central driver of IoT adoption through the concept of IoT synergy.

3. Methodology

3.1. Research Design

This study adopts a mixed-method research design, integrating both quantitative and qualitative approaches to provide a comprehensive understanding of IoT adoption in Nepal. The quantitative component focuses on identifying and measuring the key determinants influencing IoT adoption, while the qualitative component supports deeper interpretation through respondents’ perspectives on collaboration and ecosystem dynamics.

The study is primarily descriptive and analytical in nature, aiming to examine relationships among variables rather than establishing causal inference. This design is appropriate for

emerging research areas where exploratory insights are required.

3.2. Data Collection

Primary data were collected through a structured questionnaire targeting professionals, firms, and stakeholders involved in IoT-related activities in Nepal. The respondents included individuals from technology companies, startups, academic institutions, and ICT-related organizations.

The questionnaire was divided into two sections:

- **Closed-ended questions** using a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) to measure key variables
- **Open-ended questions** to capture qualitative insights on collaboration and challenges

A purposive sampling technique was used to select respondents with relevant experience in IoT or related digital technologies.

3.3. Data Analysis Techniques

Quantitative data were analyzed using Statistical Package for Social Sciences (SPSS). The following analytical techniques were employed:

- Descriptive statistics (mean, standard deviation) to summarize responses
- Reliability analysis using Cronbach’s Alpha to ensure internal consistency of constructs

Qualitative responses were analyzed using thematic analysis, allowing identification of recurring patterns related to collaboration, barriers, and opportunities.

3.4. Variables and Measurement

The study examines IoT adoption through five key independent variables and one dependent variable. All variables were measured using Likert-scale items adapted from prior technology adoption studies.

Table 1: Variables and Measurement

Variable Type	Variables Included
Dependent	IoT Adoption
Independent	Technological Readiness, Economic Feasibility, Policy Support, Market Awareness
Mediating	Collaborative Synergy

3.5. Reliability of the Instrument

To ensure the consistency of the measurement scale, Cronbach’s Alpha was calculated for all constructs. A threshold value of 0.70 or above was considered acceptable for internal reliability (Hair *et al.*, 2010) ^[5]. The results indicated that all variables met the required reliability criteria, confirming the suitability of the instrument for analysis.

3.6. Ethical Considerations

The study adhered to standard ethical research practices. Participation was voluntary and respondents were informed

about the purpose of the study. Confidentiality and anonymity of the respondents were maintained throughout the research process, and data were used solely for academic purposes.

4. Results

4.1. Descriptive Statistics

Descriptive analysis was conducted to examine the central tendency of each variable influencing IoT adoption in Nepal. The mean values indicate the relative importance of each factor as perceived by respondents.

Table 2: Descriptive Statistics

Enabler Section	Mean	Std. Deviation	Interpretation
Collaborative Enablers	4.15	0.52	High Agreement
Technological Enablers	3.84	0.61	Moderate-High
Market Enablers	3.62	0.74	Moderate
Economic Enablers	3.10	0.88	Neutral-Moderate
Policy Enablers	2.45	1.12	Low Agreement

The results show that Collaborative Synergy (Mean = 4.15) and Technological Readiness (Mean = 3.84) are the most influential factors, indicating strong agreement among respondents regarding their importance. In contrast, Policy Support (Mean = 2.45) has the lowest score, suggesting dissatisfaction with regulatory and institutional support.

4.2. Reliability Analysis

Reliability testing was conducted using Cronbach's Alpha to assess the internal consistency of the measurement scale.

Table 3: Reliability Statistics

Construct	Cronbach's Alpha
Overall Scale	0.86

The Cronbach's Alpha value of 0.801 indicates high internal consistency, confirming that the measurement items are reliable for analysis.

4.3. Key Findings

- Collaborative Synergy emerged as the strongest influencing factor, highlighting the importance of industry collaboration, knowledge sharing, and partnerships.
- Technological Readiness also shows a strong positive influence, indicating that infrastructure and technical capability are relatively well perceived.
- Economic Feasibility and Market Awareness show moderate influence, suggesting cost and awareness remain important but not dominant factors.
- Policy Support is the weakest factor, reflecting gaps in regulatory frameworks and government initiatives.

Overall, the results suggest that IoT adoption in Nepal is significantly influenced by ecosystem-level collaboration, rather than solely by traditional technological or economic factors.

5. Discussion

The findings of this study highlight that collaborative synergy plays a central role in shaping IoT adoption in Nepal, reinforcing the argument that technology diffusion in developing economies is strongly influenced by ecosystem dynamics rather than isolated factors. The high mean score for collaborative synergy indicates that interactions among industry stakeholders, academia, and support institutions significantly enhance adoption readiness. This aligns with the Triple Helix model (Etzkowitz & Leydesdorff, 2000) [3], which emphasizes the importance of collaboration among key actors in driving innovation.

The strong influence of technological readiness further supports existing literature suggesting that infrastructure and technical capability are essential prerequisites for IoT implementation (Kumar *et al.*, 2019) [6].

However, the findings indicate that technological readiness alone is not sufficient; its effectiveness is amplified when supported by collaborative networks. This suggests that technology and collaboration operate in a complementary manner, rather than independently.

The moderate impact of economic feasibility and market awareness reflects practical constraints in the Nepalese context. While cost considerations and awareness levels remain relevant, they do not appear to be the primary barriers. Instead, their influence may be indirectly shaped by collaborative mechanisms, such as shared resources, joint ventures, and knowledge dissemination, which can reduce financial and informational constraints.

The relatively low score for policy support indicates a lack of strong regulatory frameworks and institutional backing for IoT development. This finding is consistent with prior studies that identify policy uncertainty and limited government intervention as barriers in developing economies (Madakam *et al.*, 2015) [8]. The weak policy environment may also hinder the formation of structured collaborative ecosystems, further limiting large-scale adoption.

Importantly, the results extend the Technology–Organization–Environment (TOE) framework by demonstrating that collaboration functions as a mediating mechanism linking technological, economic, and environmental factors to IoT adoption. This highlights the need to move beyond traditional models and incorporate ecosystem-level interactions in understanding technology adoption.

Overall, the study suggests that IoT adoption in Nepal is not merely a function of technological availability or financial capacity, but is significantly driven by the strength and quality of collaboration among stakeholders. Strengthening these collaborative networks can therefore serve as a strategic pathway to accelerate IoT diffusion in the country.

6. Conclusion and Recommendations

6.1. Conclusion

This study examined the role of collaboration in influencing IoT adoption in Nepal through the concept of IoT synergy. The findings reveal that while technological readiness remains an important factor, collaborative synergy is the most influential determinant of IoT adoption. The study demonstrates that effective interaction among industry players, academia, and supporting institutions significantly enhances adoption readiness and implementation capacity. Economic feasibility and market awareness were found to have moderate influence, indicating that financial and informational constraints exist but are not the primary barriers. In contrast, policy support emerged as the weakest factor, highlighting gaps in regulatory frameworks and institutional facilitation.

Overall, the study concludes that IoT adoption in Nepal is ecosystem-driven, where collaboration acts as a critical enabler linking technological, economic, and environmental

dimensions. Without strong collaborative structures, IoT initiatives are likely to remain fragmented and limited in scale.

6.2. Recommendations

Based on the findings, the following recommendations are proposed:

- **Strengthen Industry Collaboration:** Encourage partnerships among firms, startups, and technology providers to promote knowledge sharing and joint innovation.
- **Promote Academia–Industry Linkages:** Establish collaborative platforms for research, training, and skill development in IoT-related fields.
- **Enhance Policy and Regulatory Support:** Government agencies should develop clear policies, incentives, and strategic frameworks to support IoT ecosystem growth.
- **Facilitate Innovation Ecosystems:** Support the development of innovation hubs, incubators, and networking platforms to foster collaboration among stakeholders.
- **Increase Awareness and Capacity Building:** Conduct training programs, workshops, and awareness campaigns to improve understanding and adoption of IoT technologies.

By focusing on these areas, Nepal can develop a more integrated and collaborative IoT ecosystem, enabling scalable and sustainable adoption across sectors.

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