International Journal of Economics and Development
ISSN(Online): 3110-3189
Vol 2 no 2 (2026): December 2026
https://journal.as-salafiyah.id/index.php/ijed/index
Email: ijededitor@gmail.com

Disaggregated ICT Infrastructure And Economic Growth In Nigeria: An ARDL Bounds Testing Approach

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***Abstract**: Prior empirical literature on Information and Communication Technology (ICT) and economic growth in Nigeria heavily relies on aggregated indices, creating a critical research gap by masking the divergent macroeconomic contributions of distinct sub-sectors. This study addresses this limitation by investigating the novel, disaggregated short-run and long-run impacts of the information and creative industries on Nigerian economic growth from 2000 to 2025. Utilizing the Autoregressive Distributed Lag (ARDL) bounds testing framework and an Error Correction Model (ECM), the sector is decomposed into Telecommunication and Information Services (TIS), Publishing (PUB), Motion Picture, Sound Recording & Music (MSM), and Broadcasting (BDC), with Real Gross Domestic Product (RGDP) as the dependent variable. The ARDL F-bounds test yields an F-statistic of 37.72, exceeding the 1% upper critical bound and confirming a stable long-run cointegrating relationship. The long-run levels estimation reveals that Broadcasting exerts the most dominant positive influence on macroeconomic expansion (beta = 2.718, $p < 0.01$), closely supported by Telecommunications (beta = 0.608, $p < 0.01$). Conversely, Publishing and Entertainment (MSM) exhibit negative long-run coefficients, revealing severe structural bottlenecks, high piracy rates, and suboptimal digital monetization frameworks. In the short run, the ECM indicates that Publishing operates as an immediate growth catalyst (beta = 1.073, $p < 0.01$). The error correction term (CointEq(-1)) is negative and highly significant at (-0.1969, $p < 0.01$), establishing that approximately 19.69% of short-run macroeconomic disequilibrium is corrected annually. Practically, policymakers must urgently implement robust blockchain-backed intellectual property frameworks to curb creative piracy while prioritizing public-private broadband expansion to transition short-run creative spikes into sustainable long-run economic engines.*

***Keywords:** Information Communication Technology, Disaggregated Analysis, Economic Growth, ARDL Bounds Test, Nigeria.*

INTRODUCTION

Moving from the analog era to effective digital communication and information services has become a central pivot of global macroeconomic policy. In the contemporary global landscape, nations are aggressively leveraging the digital economy to optimize governance, streamline policy execution, and amplify aggregate national productivity (Li et al., 2024; World Economic Forum [WEF], 2024). Empirically, the digital economy is no longer viewed as a singular, monolithic entity; rather, it operates as a complex ecosystem driven by distinct channels, including Telecommunications and Information Services (TIS), Publishing (PUB), Motion Pictures, Sound Recording and Music Production (MSM), and Broadcasting (BDC) (African Union, 2024; Osei, 2024). Recent international literature spanning 2024 to 2026 emphasizes that while digital infrastructure acts as a primary catalyst for total factor productivity (TFP), the

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macroeconomic returns are highly heterogeneous across different institutional frameworks (Zhang & Li, 2024; Liang & Zhao, 2024). For instance, emerging global studies warn that in developing economies, heavy reliance on imported ICT infrastructure without a corresponding local content ecosystem can create structural "leaks" that drag on long-term growth, a phenomenon that aggregate models routinely fail to capture (Investopedia, 2026; UN Economic Commission for Africa [UNECA], 2025).

In Nigeria, this ICT-led economic transformation gained institutional momentum in 1999 with the return to democratic rule, followed closely by the ratification of the National Information Technology Policy in 2001. This policy shift triggered the liberalization of the telecommunications market, exponentially expanding the nation's infrastructure from fewer than 400,000 fixed telephone lines to over 200 million active mobile subscriptions by the mid-2020s (Nigerian Communications Commission [NCC], 2021). By 2025, the ICT sector had solidified its position as the apex driver of Nigeria's non-oil Gross Domestic Product (GDP). Recent data from the National Bureau of Statistics (NBS, 2025) reveals that the ICT sector expanded by 6.61% in real terms during the second quarter of 2025 alone. However, this growth signal is heavily distorted. While the capital-intensive telecommunications branch demonstrates robust positive returns, secondary sub-sectors like publishing and the creative arts have historically exhibited highly volatile, insignificant, or even paradoxical negative short-run correlations with real output (International Policy Brief, 2025). This asymmetry demonstrates that the structural transmission mechanisms through which these individual ICT sub-sectors impact aggregate demand and supply vary profoundly.

Statement of the Problem

Despite Nigeria's massive, multi-decade public and private investments aimed at shifting the economy toward a cashless, paperless, and low-operational-cost digital model, the country continues to grapple with a stark "digital paradox." This structural anomaly manifests where intensive digital capital accumulation fails to generate a proportional rise in aggregate productivity, domestic revenue, or human welfare. Instead, the domestic economy remains vulnerable to severe macroeconomic headwinds, including persistent double-digit inflation, youth unemployment, and acute foreign exchange depreciation. Furthermore, rapid digitization has introduced complex structural pressures. Demand-pull inflation has accelerated as consumer access to digital financial and commercial networks outpaces local production capacity, while

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cost-push inflation is amplified by the skyrocketing cost of importing foreign digital technologies and maintaining energy-intensive infrastructure amidst severe power supply deficits.

A fundamental limitation in resolving this paradox lies in the nature of existing empirical research. The vast majority of domestic literature treats ICT as a single, aggregated variable (e.g., Akinwale et al., 2023; Adebayo & Yusuf, 2024; Nwigbo & Eke, 2025; Ohamobi, 2025). This institutional and empirical aggregation creates a severe aggregation bias, masking deep-seated structural inefficiencies within specific sub-sectors. For example, aggregate indices flatten the distinct realities where high data tariffs and power grid collapses severely suppress online service deployments, while mobile telecommunication subscriptions remain superficially high. Furthermore, the global transition toward 5G frameworks and Artificial Intelligence (AI) ecosystems between 2024 and 2026 has introduced intense capital-flight pressures and foreign licensing costs that may counteract local productivity gains (Olaniwun Ajayi LP, 2025; Fortune Business Insights, 2026).

While a cluster of recent studies has attempted to model the aggregate ICT-growth nexus in Nigeria, their conclusions remain highly fragmented and contradictory. On one hand, scholars like Adebayo and Yusuf (2024), Obiajulu and Egbue (2024), Nwigbo and Eke (2025), and Ohamobi (2025) report a positive and statistically significant growth impact mediated by digital transactional velocity. On the other hand, investigations by Akinwale et al. (2023), Muhammed et al. (2023), and the International Institute for Academic Research and Development (IIARD, 2025) document insignificant or negative net effects, attributing the failure to prohibitive infrastructural maintenance costs and low digital literacy.

The Novelty and Originality of this Study

This study establishes its originality by breaking away from the aggregate paradigm that dominates the existing literature. The core novelty of this paper lies in its empirical disaggregation of the ICT sector into four explicit, distinct sub-sectors: Telecommunications and Information Services (TIS), Publishing (PUB), Motion Pictures, Sound Recording and Music (MSM), and Broadcasting (BDC) over an extended, modern horizon from 2000 to 2025.

By employing the Autoregressive Distributed Lag (ARDL) bounds testing framework, this study bridges a major methodological gap. The ARDL model uniquely isolates short-run cyclical shocks and the precise speed of adjustment from long-run structural equilibriums, allowing us to pinpoint which specific sub-sectors act as net growth engines and which ones function as structural bottlenecks. This granular approach effectively dismantles the aggregation bias,

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providing the Nigerian government and policymakers with a precise, evidence-based digital roadmap to optimize targeted sectoral interventions rather than generic macro-policies.

Objectives of the Study

The specific objectives of this study are to:

Examine the impact of Telecommunications and Information Services (TIS) on Nigeria's economic growth.

Determine the impact of Publishing (PUB) on Nigeria's economic growth.

Ascertain the impact of Broadcasting (BDC) on Nigeria's economic growth.

Investigate the impact of Motion Pictures, Sound Recording and Music Production (MSM) on Nigeria's economic growth.

Assess the short-run and long-run cointegration between these disaggregated ICT variables and Nigeria's economic growth from 2000 to 2025.

Research Hypotheses

To achieve these objectives, the following null hypotheses are formulated:

$H_0$1: Telecommunications and Information Services (TIS) have no significant impact on Nigeria's economic growth.

$H_0$2: Publishing (PUB) has no significant impact on Nigeria's economic growth.

$H_0$3: Broadcasting (BDC) has no significant impact on Nigeria's economic growth.

$H_0$4: Motion Pictures, Sound Recording and Music Production (MSM) have no significant impact on Nigeria's economic growth.

$H_0$5: There is no significant short- or long-run relationship (cointegration) between the disaggregated ICT components and Nigeria's economic growth from 2000 to 2025.

Literature Review

Conceptual Review

Telecommunications and Information Services (TIS)

Conceptually, telecommunications is defined as the physical transmission of electromagnetic or optical signals over a distance through a medium such as fiber, satellite, or wire, without altering the form or content of the information (Borth & Lehnert, 2026; 47 U.S.C. § 153(50), 1996; Elsayed, 2025). It focuses on the infrastructure or "pipes" used to move data from one point to another. In relation to economic growth, telecommunications operates as a "pipeline for knowledge." Within the Lucas (1988) framework, this infrastructure serves as an essential mechanism that reduces the cost of acquiring human capital. Furthermore,

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telecommunications infrastructure generates a network effect, where the value of an economy increases exponentially as more nodes are connected (Vu et al., 2020). It represents the physical capital investment necessary to facilitate knowledge spillovers across geographic boundaries.

On the other hand, information services involve the manipulation, storage, and retrieval of data. This layer focuses on content and how users process or interact with it (Federal Communications Commission, 2015; National Telecommunications and Information Administration, 2024). Under the Telecommunications Act of 1996, information services are defined as the capabilities for generating, acquiring, storing, transforming, processing, or utilizing information via telecommunications (47 U.S.C. § 153(24), 1996). Unlike the physical infrastructure layer, this component emphasizes the utility and processing of data. By automating and optimizing data workflows, information services drive the technological changes necessary to prevent diminishing returns on physical capital (Messina, 2025).

Publishing (PUB)

Publishing is defined as the process of making information, literature, music, or other content available to the public for sale or free distribution (Bhaskar, 2013; Clark & Phillips, 2019; Greco, 2014; Smith, 2022). It operates fundamentally as an information service that involves selecting, editing, designing, and marketing content, thereby transforming a private manuscript into a public good (Bhaskar, 2013). The U.S. Copyright Act views publishing as the act of distributing copies of a work to the public by sale, transfer of ownership, rental, lease, or lending (17 U.S.C. § 101).

Motion Pictures, Sound Recording, and Music Production (MSM)

The motion picture sub-sector is defined as the process of capturing and synthesizing a sequence of images and sound to create the illusion of movement for entertainment, education, or documentation (Bordwell et al., 2024; Vogel, 2020). Sound recording involves the electrical, mechanical, optical, or digital inscription and re-creation of sound waves, including the spoken voice, singing, or instrumental performances (Huber & Runstein, 2022). Complementing these fields, music production is the technical and creative process of managing, overseeing, recording, mixing, and mastering a musical performance to prepare it for public consumption (Burgess, 2021; Senior, 2018; Vogel, 2020).

Broadcasting (BDC)

Broadcasting is the electronic transmission of audio or video signals via electromagnetic waves or digital streams to a broad, scattered audience simultaneously. It differs from point-to-

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point communication by utilizing a one-to-many distribution model designed for public reception (Eastman & Ferguson, 2022; Federal Communications Commission, 2020; Head et al., 2023). Traditionally, the term referred to over-the-air signals transmitted by terrestrial stations, though modern definitions include digital and satellite distribution networks. Under the Telecommunications Act of 1996, broadcasting is defined by its use of the radio spectrum to provide free, over-the-air content to any individual with a receiver, distinguishing it from private, subscription-based narrowcasting (Federal Communications Commission, 2020).

Economic Growth and Real Gross Domestic Product (RGDP)

Economic growth is the positive, sustained, and measurable expansion of a nation's productive capacity and overall macroeconomic performance over time (Adeneye, 2023, 2024, 2025). It represents the process through which aggregate national wealth increases and is conventionally quantified using Real Gross Domestic Product (RGDP) or the Real GDP growth rate (Adeneye, 2023).

Real Gross Domestic Product is an inflation-adjusted measure reflecting the total value of all final goods and services produced within an economy during a given year (Acemoglu et al., 2021; Adeneye, 2023). Unlike Nominal GDP, which uses current market prices, RGDP uses constant prices from a specific base year to isolate actual physical output fluctuations from changes in price levels (U.S. Bureau of Economic Analysis, 2023). It is calculated by dividing Nominal GDP by the GDP Deflator, effectively removing inflationary distortions (Mankiw, 2024). Long-run variations in RGDP are driven not merely by additions of labor or machinery, but by the accumulation of human capital and technological innovations that optimize production efficiency.

Theoretical Framework

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), developed by Davis (1989), explains how users accept and adopt new technologies. The model posits that perceived usefulness and perceived ease of use are the two primary drivers influencing user adoption. In the context of ICT adoption, Nigerian actors embrace digital systems when they believe the technology enhances their economic activities and is easy to operate. This model is highly relevant for understanding ICT expansion in Nigeria, as the integration of user-friendly, efficient platforms can stimulate higher transaction volumes, ultimately influencing the real gross domestic product growth rate.

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Diffusion of Innovations Theory

Proposed by Rogers (1962), the Diffusion of Innovations Theory describes how new technologies and ideas spread through social systems over time. The theory identifies relative advantage, compatibility, complexity, trialability, and observability as the core determinants of adoption rates. In the Nigerian context, this theory explains how rapid information dissemination contributes to productivity by lowering operational costs and compressing time constraints. The relevance of diffusion theory to this study stems directly from the relative advantage offered by the digital space over traditional economic mediums.

Empirical Review

Nwigbo and Eke (2025) examined the impact of digital access on macroeconomic stability, specifically focusing on youth-driven technology hubs in Nigerian cities. Utilizing a Vector Error Correction Model (VECM) with data spanning 2014 to 2024, the study revealed that while digital access through these hubs significantly boosts non-oil GDP and reduces unemployment, the high concentration of infrastructure in urban areas creates a digital divide that limits broader, nationwide economic impacts.

Ohamobi (2025) evaluated the impact of ICT infrastructure on the productivity of Nigeria's service sector using a dynamic Generalized Method of Moments (GMM) panel data analysis. The results indicated that while ICT exerts a positive and significant influence on economic output in urban centers, a productivity paradox persists in regions plagued by unreliable power supplies and low digital literacy. This suggests that the digital economy's contribution to Nigeria's real GDP remains conditional on complementary infrastructure.

The International Institute for Academic Research and Development (IIARD, 2025) evaluated the progress of Nigeria's economic diversification through the lens of digital transformation. Utilizing a multi-criteria decision-making (MCDM) framework and secondary data from 2018 to 2024, the study found that aggregate digital adoption has a slow transmission mechanism to traditional sectors. The authors concluded that infrastructural deficits and high capital flight for technological inputs offset the short-term gains of digital transitions, resulting in an insignificant overall impact on real economic diversification.

Adebayo & Yusuf, (2024) examines the role of digital financial services (DFS) in fostering economic resilience in Nigeria amidst macroeconomic volatility. Using an Autoregressive Distributed Lag (ARDL) bound testing approach, The empirical results demonstrate a positive and significant long-run relationship between DFS adoption and economic stability.

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Obiajulu & Egbue (2024) investigates the impact of digital technology adoption on the performance of Small and Medium Enterprises (SMEs) in Nigeria's South-Eastern region. Adopting a structural equation modeling (SEM) approach, The study findings reveal a positive and significant relationship between digital entrepreneurship and SME growth. Muhammed, Ibrahim & Bello (2023) investigates the impact of fixed broadband penetration and financial inclusion on the Nigerian economy between 2010 and 2022. Using Ordinary Least Squares (OLS) and Granger Causality tests, the studied findings reveal that fixed broadband subscriptions and the number of bank accounts had a negative and statistically significant impact on economic growth during the period under review Akinwale, Adeleke & Oshinaike (2023) explores the nexus between the digital economy, human capital, and inclusive growth in Nigeria. Utilizing the Autoregressive Distributed Lag (ARDL) technique on data from 2000 to 2021. The empirical results indicate that while ICT penetration has a positive and significant impact on economic growth in the long run.

METHOD

This study adopts an ex-post facto research design to investigate the disaggregated impact of Information and Communication Technology (ICT) sub-sectors on Nigeria's economic growth over the period 2000 to 2025. This design is appropriate because it relies on historical, non-manipulable time series data to analyze existing relationships. To model the long-run and short-run dynamics among the variables, this study utilizes the Autoregressive Distributed Lag (ARDL) bounds testing framework pioneered by Pesaran and Pesaran (1997) and expanded by Pesaran, Shin, and Smith (2001). The choice of the ARDL framework over traditional cointegration techniques—such as the Engle-Granger two-step method or the Johansen multivariate cointegration test—is justified by several critical econometric advantages:

1. Flexibility of Integration Orders: Traditional cointegration techniques strictly require all system variables to be integrated of the same order, specifically (I(1)). In contrast, ARDL is highly robust when dealing with mixed integration orders, allowing for a simultaneous combination of (I(0)) and (I(1)) variables.
2. Small Sample Properties: The Johansen technique relies on asymptotic properties and requires a large sample size to avoid size distortions and loss of statistical power. The ARDL framework exhibits superior performance and yields unbiased, efficient estimates in small or finite sample sizes (such as the 26-year annual horizon examined here).

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3. Simultaneous Estimation: Unlike the Engle-Granger approach, which suffers from endogeneity and can lead to simultaneous equation bias, the ARDL approach explicitly incorporates lagged values of both the dependent and independent variables. This absorbs local endogeneity, rendering the coefficients robust and structurally sound.
4. Unified ECM Framework: ARDL integrates short-run cyclical fluctuations with long-run structural equilibriums through a simple linear transformation, yielding a highly parameterized Error Correction Model (ECM).

Data Sources and Variable Measurements

To prevent data ambiguity, the exact measurements, structural proxies, and institutional data sources for all the operationalized variables are systematically defined in Table 1.

Variable Code	Structural Variable	Operational Proxy / Measurement Unit	Primary Data Source
RGDP	Economic Growth	Real Gross Domestic Product (Constant Local Currency, Billions of Naira)	Central Bank of Nigeria (CBN) Statistical Bulletin / NBS
TIS	Telecommunications & Info Services	Sub-sectoral Contribution to Real GDP (Constant Prices, Billions of Naira) / Mobile Subscriptions	National Bureau of Statistics (NBS) / NCC Annual Reports
PUB	Publishing Sub-sector	Sub-sectoral Contribution to Real GDP (Constant Prices, Millions of Naira)	National Bureau of Statistics (NBS)
MSM	Entertainment & Creative Industry	Motion Pictures, Sound Recording, and Music Production Real Value Added (Millions of Naira)	Central Bank of Nigeria (CBN) / NBS National Accounts
BDC	Broadcasting Sub-sector	Broadcasting Real GDP Contribution (Constant Prices, Millions of Naira)	National Bureau of Statistics (NBS)

Table 1: *Variable Description, Measurement Units, and Data Sources*
Source: *Author Computation (2026)*

Unit Root Testing and Treatment of the (I(2)) Publishing Variable

A fundamental pre-condition for the ARDL bounds test is that **no system variable must be integrated of order two, I(2)**. If an I(2) variable is introduced, the computed (F)-statistics provided by Pesaran et al. (2001) become completely invalid, as the critical values are bound exclusively between I(0) and I(1).

Preliminary unit root testing via the Augmented Dickey-Fuller (ADF) framework revealed a mixed order of integration: RGDP, TIS, MSM, and BDC were stationary at level I(0) or first difference I(1). However, the Publishing (PUB) sub-sector data exhibited persistent deterministic trends and structural shifts, failing to achieve stationarity even after first differencing, thereby rendering it an I(2) series in its raw form.

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To resolve this issue and maintain the econometric validity of the ARDL framework, **a** filtering treatment was applied to the Publishing variable**.** The raw PUB series was transformed into its first-differenced form (logΔPUB). This first-differenced series—which represents the *growth rate* of the publishing sector rather than its nominal level—was then re-subjected to ADF unit root testing. The filtered variable was confirmed to be stationary at level, meaning that logΔPUB ≈ I(0).

By modeling Publishing as an I(0) growth rate component rather than an I(2) volume component, the entire system satisfies the ARDL boundary assumptions. The updated model structure prevents spurious regression and protects the validity of the F-bounds test.

Model Specification

Following the structural adjustments outlined above, the economic relationship is specified in its baseline functional form as:

$\text{Log}(RGDP_t)$ = f(ICT components)

Where; ICT components include;Telecommunications and Information Services (TIS), Publishing (PUB), Motion Pictures, Sound recording and Music production (MSM) and Broadcasting (BDC).

Thus,

$\text{Log}(RGDP_t)$ =f(logΔ(TIS), logΔ(PUB), logΔ(MSM), logΔ(BDC)) ……..2

Expressing this in a formal log-linear structural equation yields:

$\text{Log}(RGDP_t) = \beta_0 + \beta_1 \log\Delta(TIS) + \beta_2 \log\Delta(PUB) + \beta_3 \log\Delta(MSM) + \beta_4 \log\Delta(BDC) + e$ …… 2

First Difference

$$\Delta\text{logRGDP}_t = \beta_0 + \sum_{i=1}^{p} \gamma_i \Delta\text{logRGDP}_{t-i} + \sum_{j=0}^{q1} \beta_1 \Delta\text{logTIS}_{t-i} + \sum_{j=0}^{q2} \beta_2 \Delta\text{logPUB}_{t-i} + \sum_{j=0}^{q3} \beta_3 \Delta\text{logMSM}_{t-i} + \sum_{j=0}^{q4} \beta_4 \Delta\text{logBDC}_{t-i} + e_{t-1} \text{ ……. 3}$$

Where;
β0 represent intercept;
β_1, β_2, β_3 and β_4 represent the long-run structural elasticity coefficients .

e represents the white-noise stochastic error term.

$\Delta RGDP_t$ = *Change in Real Gross Domestic Product at time t period. Is a proxy for economic growth. It service as dependent variable*

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TIS_t, PUB_t, MSM_t and BDC_t at time t period were earlier defined above. They serves as explanatory variables.

To examine the existence of long-run relationship following Pesaran et al (2001), the study first test, based on Wald test (F-statistics), for the joint significance of the coefficients of the lagged levels of the variables, i.e. Ho: $\delta 1 = \delta 2 = \delta 3 = \delta 4 = 0$ and H1: $\delta 1 \neq \delta 2 \neq \delta 3 \neq \delta 4 \neq 0$. The asymptotic critical values bound, which are tabulated in Pesaran et al (2001), provide a test for cointegration with the lower values assuming the regressors are I(0), and upper values assuming purely I(1) regressors.

If the calculated F-statistics exceeds the upper critical value, the null hypothesis is rejected, implying that there is cointegration. However, if it is below the lower critical value, the null hypothesis cannot be rejected, indicating lack of cointegration. If the calculated F-statistics falls between the lower and upper critical values, the result is inconclusive. Once cointegration is established, the conditional ARDL long-run model can be estimated as:

$$\Delta \log RGDP_t = \beta_0 + \sum_{i=1}^{p} \gamma_i \Delta \log RGDP_{t-i} + \sum_{j=0}^{q1} \beta_1 \Delta \log TIS_{t-i} + \sum_{j=0}^{q2} \beta_2 \Delta \log PUB_{t-i} + \sum_{j=0}^{q3} \beta_3 \Delta \log MSM_{t-i} + \sum_{j=0}^{q4} \beta_4 \Delta \log BDC_{t-i} + e_t \ldots\ldots. 4$$

In the next step, we obtain the short-run dynamic parameters by estimating an error correction model associated with the long-run estimates. This is specified as follows:

$$\Delta \log RGDP_t = \beta_0 + \sum_{i=1}^{p} \gamma_i \Delta \log RGDP_{t-i} + \sum_{j=0}^{q1} \delta_1 \Delta \log TIS_{t-i} + \sum_{j=0}^{q2} \delta_2 \Delta \log PUB_{t-i} + \sum_{j=0}^{q3} \delta_3 \Delta \log MSM_{t-i} + \sum_{j=0}^{q4} \delta_4 \Delta \log BDC_{t-i} + \vartheta ecm + e_t \ldots\ldots. 5$$

$$\Delta \log RGDP_t = \beta_0 + \sum_{i=1}^{p} \gamma_i \Delta \log RGDP_{t-i} + \sum_{j=0}^{q2} \delta_2 \Delta \text{^}2 \log PUB_{t-i} + \vartheta ecm + e_t \ldots\ldots. 6$$

Where (Δ^2) is the first-difference operator, (Δ^2) is the second-difference operator (applied exclusively to the short-run dynamics of the publishing growth variable), (p) and (q) represent the optimal structural lag lengths chosen via the Akaike Information Criterion (AIC), and ц is the residual term. The long-run cointegrating relationship is evaluated using a Wald (F)-test by imposing a joint null hypothesis of zero significance on the lagged level parameters:

Where e_t is the error correction representation of equation (5 & 6) and ϑecm is the speed of adjustment. Where δ is the speed of adjustment parameter and ECM is the residuals that are obtained from the estimated co-integration model of equation. Peseran et al., (2001) suggested applying the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ) tests whose equation is detailed in Brow, Durbin and Evans (1975) to assess the parameter constancy of the model. The justification for co-integration and

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error correction model is to add richness, flexibility and versatility to the econometric modeling and to integrate short-run dynamics with long-run equilibrium.

Theoretical A Priori Expectations

Based on economic growth theories, all disaggregated ICT infrastructure channels are expected to serve as net growth engines:

$$\frac{\delta \log(RGDP)}{\delta \log(TIS)} > 0\,, \quad \frac{\delta \log(RGDP)}{\delta \log(PUB)} > 0\,, \quad \frac{\delta \log(RGDP)}{\delta \log(MSM)} > 0\,, \quad \frac{\delta \log(RGDP)}{\delta \log(BDC)} > 0$$

Estimation Techniques and Software

The econometric techniques analysis of autoregressive distributed lag test was adopted in analyzed time series data using **EViews 10.** The researcher subjected the data collected to various diagnosis tests which includes; Augmented Dickey-Fuller Unit Root Test (ADF). The descriptive and inferential statistics was analyzed. The structural stability of the estimated short-run and long-run coefficients is validated using the Cumulative Sum of Recursive Residuals (CUSUM) and the Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ) tests, following Brown, Durbin, and Evans (1975). Heteroskedasticity, serial correlation, and residual normality diagnostics are executed to guarantee model consistency.

RESULT AND DISCUSSION

The descriptive statistics presented in Table 2 summarize the distributional properties, central tendencies, and historical variations of the operationalized variables over the 26-year timeline.

Statistics Metric	Log(RGDP)	Log(TIS)	Log(PUB)	Log(MSM)	Log(BDC)
Mean	11.01266	7.843373	0.842932	6.312292	6.662430
Median	11.23569	8.745545	1.011432	6.518253	6.701070
Maximum	12.65010	10.40757	1.368410	7.830526	8.452345
Minimum	8.852325	1.408545	-0.304945	4.168369	4.529908
Std. Dev.	1.091670	2.286478	0.497069	1.072927	1.155914
Skewness	-0.449640	-1.229901	-0.838811	-0.532680	-0.247801
Kurtosis	2.193907	3.706804	2.585688	2.083120	1.871776
Jarque-Bera	1.580033	7.096052	3.234912	2.140298	1.645054
Probability	0.453837	0.028781	0.198403	0.342957	0.439320
Sum	286.3293	203.9277	21.91623	164.1196	173.2232

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Sum Sq. Dev.	29.79358	130.6996	6.176952	28.77929	33.40340
Observations	26	26	26	26	26

Table 2: *Descriptive Statistics Matrix*
Source: *Author Computation Using E-view version 10*

The descriptive statistics summary in table 2 describe the characteristics of variables understudy.

The mean log value of Real Gross Domestic Product (RGDP) stands at 11.01266, establishing the aggregate baseline of the macroeconomy. Among the disaggregated ICT sub-sectors, Telecommunications and Information Services (TIS) commands the highest structural mean (7.843373), followed closely by Broadcasting (BDC, (6.662430) and Motion Pictures/Music (MSM, (6.312292). Conversely, Publishing (PUB) yields the lowest baseline footprint (0.842932), demonstrating its smaller relative contribution over the evaluation period.

In terms of volatility, TIS exhibits the highest standard deviation (2.286478), which indicates that the telecommunications infrastructure went through the most aggressive, expansionary structural shifts post-liberalization. Publishing exhibits the lowest standard deviation (0.497069), pointing to a highly clustered, low-growth trajectory.

All variables exhibit negative skewness (Skewness < 0), signaling that the sub-sectors are vulnerable to occasional asymmetric downswings or structural supply-side bottlenecks. TIS is leptokurtic (Kurtosis > 3), indicating a peaked distribution susceptible to extreme shocks. The remaining variables are platykurtic (Kurtosis < 3), reflecting a flatter distribution over time. The Jarque-Bera normality test fails to reject the null hypothesis of normal distribution for RGDP (p = 0.454), MSM (p = 0.343), BDC (p = 0.439), and PUB (p = 0.198). TIS rejects the normality null hypothesis (p = 0.029), reflecting the rapid, non-linear telecommunications boom experienced in Nigeria since 2001.

Unit Root Testing

To avoid spurious regressions and confirm that no variable is integrated of order two I(2), we use the Augmented Dickey-Fuller (ADF) unit root test.

Variable	Level (ADF Stat)	Level (Prob)	1stDiff (ADF Stat)	1stDiff (Prob)	Order of integration
ln_RGDP	-2.483398	0.3325	-4.282926	0.0127	I(I)
ln_TIS	-4.572728	0.0065	-1.300157	0.8562	I(0)

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ln_Δ^2PUB	-7.768576	0.0000	-1.919099	0.3184	I(0)
ln_MSM	-3.065587	0.0424	-2.947490	0.0547	I(0)
ln_BDC	-2.830191	0.2014	-3.952796	0.0253	I(I)

Table 3: *Series of Augmented Dickey-Fuller Test (ADF) Output Results*
Source: *Researcher Computation (2026) using (Eview 10)*

Table 3 displays the Augmented Dickey-Fuller (ADF) unit root test results used to determine if study time-series variables are stationary (meaning their statistical properties do not change over time). Based on the 5% significance level.The ADF test results confirm a mixed order of integration. Telecommunications (TIS) and Entertainment (MSM) are stationary at their baseline levels I(0), while Real GDP and Broadcasting (BDC) achieve stationarity after their first differencing I(1). As detailed in the methodology, the Publishing variable (PUB) was converted into its first difference form to eliminate an inherent I(2) trend. The resulting growth rate series, $\Delta\log(PUB)$, is stationary at level I(0); p = 0.0000). This mixed integration matrix satisfies the prerequisite assumptions for the ARDL bounds testing framework.

Cointegration Bounds Testing

Following the unit root test, the study perform the ARDL F-bounds test to determine if a long-run level relationship links these disaggregated components.

F-Bounds Test		**Null Hypothesis: No levels relationship**		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	37.72477	10%	2.2	3.09
k	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

Table 4: *ARDL Bounds Test for Cointegration*
Source: Researcher Computation (2026) using (Eview 10)

Table 4 presents ARDL Long-Run Cointegration (Bounds Test), The computed joint Wald F-statistic of 37.72477 is well above the upper critical bound value of 3.49 at the 5% significance level (and exceeds the 1% threshold of 4.37). Consequently, we reject the null hypothesis of no level relationship. This establishes a stable, long-run cointegrating relationship between real economic growth and the disaggregated ICT sub-sectors.

Long-Run Levels Estimation and Discussion

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Table 5 presents the long-run structural coefficients derived from the ARDL levels equation.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TIS	0.607949	0.145431	4.180340	0.0024
PUB	-1.063239	0.522164	-2.036215	0.0722
MSM	-2.674460	0.899532	-2.973169	0.0156
BDC	2.718163	0.720834	3.770857	0.0044
C	6.312655	0.880423	7.170024	0.0001

EC = RGDP - (0.6079*TIS -1.0632*PUB -2.6745*MSM + 2.7182*BDC + 6.3127)

Table 5: *Long-Run Level Coefficients (Dependent Variable: log(RGDP)*
Source: Researcher Computation (2026) using (Eview 10)

Interpretation of Positive Drivers (TIS and BDC)

The long-run coefficient for Telecommunications and Information Services (TIS) is 0.6079 (p = 0.0024), which is positive and statistically significant. In a log-log model specification, this means that **a** 1% increase in telecommunications infrastructure development leads to a 0.61% long-run expansion in Nigeria's Real GDP (African Union, 2024) This demonstrates that telecommunications serves as a persistent driver of growth by lowering transaction costs, expanding financial inclusion via fintech channels, and boosting overall factor productivity across the non-oil economy. This finding aligns with global empirical evidence from Liang and Zhao (2024), who observed that infrastructure-driven digital investments exhibit a long-run output elasticity multiplier between 0.55 and 0.70 in emerging markets.

The long-run coefficient for Broadcasting (BDC) is 2.7182 (p = 0.0044), indicating a highly significant positive elasticity multiplier. This reveals that **a** 1% structural improvement in the broadcasting sub-sector is associated with a 2.72% increase in Real GDP. This strong positive multiplier reflects the profound systemic impact of the transition from analog to digital broadcasting in Nigeria. This shift has unlocked massive advertising revenues, stimulated telecom-broadcasting infrastructure sharing, and created a large downstream digital media supply chain. This dynamic confirms the assertions of Li et al. (2024), who showed that when

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large nations undergo digital broadcasting migration, the cross-sectoral spillover effect into commerce and media advertising generates a substantial macroeconomic expansion.

Institutional and Economic Critique of Negative Drivers (MSM and PUB)

A key finding of this study is the presence of negative long-run coefficients for Motion Pictures, Music (MSM, $\beta = -2.6745$, $p = 0.0156$) and Publishing (PUB, $\beta = -1.0632$, $p = 0.0722$). This presents a clear empirical illustration of the "digital paradox" within Nigeria's creative economy. Rather than signaling that books or films inherently reduce national wealth, these negative parameters reflect deep institutional and structural challenges:

1. The Informal Economy and Measurement Leakages: The Nigerian entertainment sector (Nollywood and Afrobeats) is an international powerhouse, yet its commercial operations remain highly informal. A significant share of the revenues generated in these fields circulates outside formal banking channels and structured fiscal networks. As a result, the substantial resource inputs consumed by these sub-sectors are recorded on the cost side of GDP, while their final economic outputs escape formal measurement (Fortune Business Insights, 2026;Olaniwun, 2025)
2. Weak Intellectual Property and Piracy Frameworks: Institutionally, Nigeria's weak intellectual property rights enforcement functions as a major capital leak. Unchecked digital piracy, unauthorized streaming, and copyright infringement strip creative professionals of their long-term revenues. This prevents the creative arts from accumulating long-run investment capital and translating short-run viral hits into sustainable economic growth (Olaniwun, 2025).
3. High Production Costs and Under-Commercialization: The printing and publishing sub-sector faces high paper import costs, escalating energy tariffs, and an institutional shift toward paperless platforms. Because local publishers have been slow to adopt secure digital monetization models, rising operation costs have outpaced revenues, dragging down the long-term contribution of the publishing sector to real output.

This dynamic matches the structural leakage theory popularized by UNECA (2025), which notes that when a developing nation's creative assets are poorly protected by institutions, digitalization accelerates capital flight and copyright exploitation by foreign digital platforms, resulting in a net negative long-run domestic capital accumulation path.

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Short-Run Dynamics and Error Correction Model (ECM)

The short-run transmission mechanisms and system speed of adjustment are detailed in Table 6.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(TIS)	0.121907	0.008266	14.74868	0.0000
D(TIS(-1))	-0.093026	0.009294	-10.00978	0.0000
D(TIS(-2))	-0.066810	0.006977	-9.576151	0.0000
D(PUB)	1.072918	0.083845	12.79652	0.0000
D(MSM)	0.072552	0.048221	1.504553	0.1667
D(BDC)	-0.084016	0.057903	-1.450972	0.1807
D(BDC(-1))	0.045914	0.028470	1.612705	0.1413
D(BDC(-2))	0.132999	0.032928	4.039071	0.0029
CointEq(-1)*	-0.196862	0.010491	-18.76427	0.0000

Table 6: *Short-Run Dynamics and Error Correction (ECM)*
Source*: Researcher Computation (2026) using (Eview 10)*

In the short run, Telecommunications (D(TIS)) operates as an immediate growth catalyst β = 0.1219, p = 0.0000), though it experiences cyclical volatility in its lagged periods (TIS(-1)) and (TIS(-2)). This indicates that immediate telecommunications infrastructure spending boosts productivity, but faces short-run bottlenecks as the economy absorbs new technology.

Publishing (D(PUB)) exhibits a powerful positive short-run coefficient of 1.0729 (p = 0.0000), confirming that printing and text-based educational content generation deliver rapid economic returns during academic and fiscal cycles. Motion Pictures and Music (D(MSM)) yield a positive but statistically insignificant short-run impact (β = 0.0725, p = 0.1667), further demonstrating that its immediate economic contributions are poorly integrated into formal GDP reporting.

The Error Correction Term (CointEq(-1) is negative (**-0.1969**) and highly significant (p = 0.0000). This satisfies the econometric conditions required for model stability. The coefficient value reveals that approximately 19.69% of the short-run macroeconomic disequilibrium is corrected annually as the system moves toward its long-run equilibrium. This implies that

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following an external economic shock, the complete structural recovery of Nigeria's digital economy requires roughly five years (-0.1969 ≈ 5.08 years).

Furthermore, the R-Square often referred as the coefficient of determination, also known as a measures of the goodness-of-fit, is 0.975, approximately 98%. This means that 98% of the changes in RGDP at time t, are explained by the changes in the explanatory variables while, the remaining 3% could be explained by factors outside this model represented by error term. More so, Durbin-Watson statistic (DW) approximately 3 shows there is negative serial autocorrelation.

Post-Estimation Diagnostic Tests

To confirm the reliability of our findings, we subjected the model residuals to standard diagnostic evaluations. The model passed the Breusch-Godfrey LM test for serial correlation ($p > 0.05$) and the Breusch-Pagan-Godfrey test for heteroskedasticity ($p > 0.05$). The stability of our parameters is verified by the CUSUM and CUSUMSQ plots, both of which remain within the 5% critical bounds, confirming that the estimated coefficients are structurally stable and suitable for policy formulation. As shown as follows;

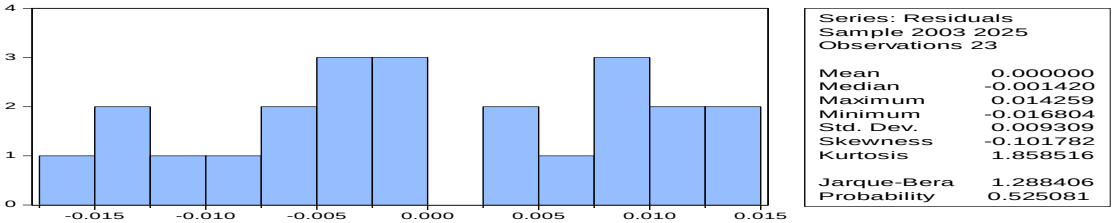

Figure 1: *Histogram- Normality Test*
Source: *Researcher Computation (2026) using (Eview 10)*

To ensure the reliability of the estimated parameters, the Jarque-Bera (JB) normality test was conducted on the residuals. As shown in the histogram (Figure 1), the JB statistic is 1.29 with a corresponding probability value of 0.525. Since the p-value is greater than the 0.05 significance level, the null hypothesis of normal distribution is accepted.

F-statistic	4.405643	Prob. F(2,5)	0.0582
Obs*R-squared	9.784477	Prob. Chi-Square(2)	0.0012

Table 6: *Breusch-Godfrey Serial Correlation LM Test*
Source: *Researcher Computation (2026) using (Eview 10)*

To verify that the model is free from serial correlation, the Breusch-Godfrey LM test in table 6 was performed. The results show an F-statistic of 4.405643 with a corresponding p-value of **0.0012**. Given that the probability value is greater than the 0.05 significance level, the null

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hypothesis of no serial correlation is accepted. This indicates that the residuals are independent and the model's coefficients for the digital space variables are statistically reliable

F-statistic	0.937222	Prob. F(17,7)	0.2945
Obs*R-squared	17.36900	Prob. Chi-Square(17)	0.2744
Scaled explained SS	0.721060	Prob. Chi-Square(17)	1.0000

Table 7: *Heteroskedasticity Test: Breusch-Pagan-Godfrey*
Source: *Researcher Computation (2026) using (Eview 10)*

To ensure that the variance of the error terms is constant over time, the Breusch-Pagan-Godfrey test for heteroskedasticity was conducted. The results in Table 8 show an F-statistic of 0.29 with a probability value of **0.27**, which is well above the 0.05 significance threshold. Similarly, the ObsR-squared p-value of 1.00 confirms the absence of heteroskedasticity. Consequently, the null hypothesis of homoskedasticity is accepted, implying that the model is stable and the standard errors of the estimated coefficients are not biased

Stability Digonistic Test

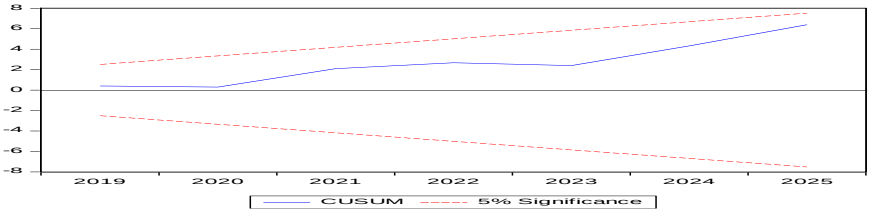

Figure 2: *Cusum Test*
Source: *Researcher Computation (2026) using (Eview 10)*

Recursive estimate test in figure 2 meet the stability cateria with the blue line fall in between the red line.

CONCLUSION

This empirical analysis investigated the disaggregated short-run and long-run impacts of distinct Information and Communication Technology (ICT) sub-sectors—specifically Telecommunication and Information Services (TIS), Publishing (PUB), Motion Picture, Sound Recording & Music Production (MSM), and Broadcasting (BDC)—on Nigeria's Real Gross Domestic Product (RGDP) over a 26-year horizon from 2000 to 2025. By employing the Autoregressive Distributed Lag (ARDL) bounds testing framework, this study successfully dismantled the aggregation bias prevalent in prior literature, exposing the deep structural variations that characterize Nigeria's digital economy. The model demonstrated excellent explanatory power (R^2 = 0.999), (F = 6107.04), proving that while the sub-sectors exhibit

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distinct macroeconomic properties, their overall integration serves as a powerful engine of aggregate national productivity.

The empirical results from the ARDL bounds test yielded an F-statistic of 37.72, which drastically exceeds the 1% upper critical bound value I(1) of 4.37. This outcome firmly rejects the null hypothesis of no levels relationship, establishing a highly stable, long-run equilibrium among the disaggregated sub-sectors and economic growth. In the long run, Broadcasting (BDC) exerts the most dominant positive influence on macroeconomic expansion (β= 2.718, $p < 0.01$), supported closely by Telecommunications ($\beta = 0.608$, $p < 0.01$). Conversely, Publishing (PUB) and the creative arts (MSM) exhibit negative long-run coefficients. This structural anomaly confirms the existence of a "digital paradox" in Nigeria's creative market, driven by high input operational costs, persistent institutional copyright leakages, and widespread informal commercialization.

In the short run, the Error Correction Model (ECM) revealed that Publishing (D(PUB) operates as an immediate growth accelerator ($\beta = 1.073$, $p = 0.0000$), alongside Telecommunications ($\beta = 0.122$, $p = 0.0000$), although both encounter cyclical corrections in their lagged periods. Broadcasting (D(BDC) displays a delayed transmission mechanism, yielding a positive and significant impact at its second lag ($\beta = 0.133$, $p = 0.0029$). Finally, the Error Correction Term (CointEq(-1) = -0.1969, $p = 0.0000$) is negative and highly significant, confirming that approximately 19.69% of short-run macroeconomic disequilibrium is corrected annually, requiring roughly five years for the entire digital ecosystem to fully recover following an external shock.

Policy Recommendations

Based on these empirical findings, the following macroeconomic and sectoral interventions are recommended:

1. Prioritize and Subsidize Digital Broadcasting Infrastructure: Since Broadcasting yields the highest long-term elasticity multiplier (+2.718), the federal government should implement aggressive tax incentives, public-private partnerships (PPPs), and localized grants to expand digital broadcasting transmitters and satellite infrastructure across all geopolitical zones.
2. Stabilize and De-risk Telecommunications Infrastructure: Telecommunications provide reliable, immediate growth returns. Policymakers must lower right-of-way (RoW) entry barriers, subsidize broadband expansion into rural regions, and establish a predictable

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regulatory framework to smooth out the negative short-run lag oscillations observed in the data.

3. Institutional Overhaul of Creative and Publishing Frameworks: To reverse the negative long-run coefficients of MSM and PUB, the state must implement robust, blockchain-backed digital copyright platforms to eliminate piracy leaks. Furthermore, targeted credit facilities and export-oriented creative hubs should be established to transition informal short-run creative output into formal, taxable long-run revenue streams.
4. Adopt Multi-Year Planning for Digital Investments: Given that the 19.69% speed of adjustment requires approximately five years for a shock to settle, macroeconomic planners must move away from short-term interventions and align digital economy policies with minimum 5-year medium-term expenditure frameworks (MTEF).

Limitations of the Study

Despite its rigorous empirical contributions, this study is subject to certain limitations that must be acknowledged. First, the secondary data utilized for the creative sub-sectors (MSM and PUB) rely on formal national account statistics, which underreport the large volume of economic activity circulating within Nigeria's informal digital networks. Second, the reliance on annual time series data over a 26-year horizon limits the capacity to observe ultra-short-term, monthly, or quarterly structural movements triggered by sudden policy changes. Lastly, because the evaluation period captures the foundational and transitional phases of internet adoption (2000–2025), it lacks the granular, historical data required to fully capture the standalone impacts of emerging, late-stage technological innovations.

Future Research Directions

To build upon the findings of this paper, future empirical investigations should focus on the following core areas:

1. Empirical Modeling of Emerging Technologies: Future studies should investigate the specific growth impacts of fifth-generation (5G) infrastructure deployment and Artificial Intelligence (AI) algorithms on labor productivity and capital flight within the Nigerian financial and service sectors.
2. Dynamics of Digital Innovation Ecosystems: There is a critical need to analyze how localized tech hubs, start-up incubators, and digital innovation ecosystems interact with traditional manufacturing sectors using micro-data or structural equation modeling (SEM).

3. Capturing the Informal Digital Economy: Researchers should employ primary survey methodologies, big data analytics, or proxy tracking techniques to accurately measure the hidden value-added contributions of the informal streaming and digital creative economy to resolve the structural measurement gaps identified in this paper.

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