

Pathways for the Digital Economy to Drive Urban-Rural Integration in Guangxi, China

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Abstract

Original Research Article

In recent years, the digital economy has emerged as a new driving force for global development, offering innovative pathways and practical experiences for urban-rural integration. Focusing on Guangxi as a case study, this paper explores how the digital economy promotes urban-rural integration through pathways such as infrastructure development, rural e-commerce growth, digital public services, and digital governance. The study finds that improved digital infrastructure fosters information sharing between urban and rural areas, rural e-commerce significantly enhances the value and competitiveness of agricultural products, digital technology improves the equity of public services, and digital governance enhances the efficiency of urban-rural coordination. However, challenges persist, including insufficient policy implementation, a shortage of technology and talent, and uneven distribution of digital infrastructure. To address these bottlenecks, the paper proposes recommendations such as enhancing infrastructure construction, strengthening talent development, optimizing policy support, and expanding application scenarios. These findings aim to provide valuable references for advancing urban-rural integration and digitalization in other less-developed regions.

Keywords: Digital Economy, Urban-Rural Integration, Guangxi, Rural E-Commerce, Digital Infrastructure, Digital Governance, Public Service Equity

1. INTRODUCTION

In recent years, the digital economy has emerged as a major driving force for global economic growth, showcasing tremendous potential and far-reaching social impacts. According to data from the China Academy of Information and Communications Technology, the total output of China's digital economy exceeded 50 trillion yuan in 2022, accounting for nearly 50% of GDP, making it a critical engine for economic development (China Academy of Information and Communications Technology, 2022). The essence of the digital economy lies in leveraging information technology to drive industrial transformation and optimize resource allocation (Gupta et al., 2021). Its influence extends beyond modernizing urban economies to promoting regional balance and fostering urban-rural integration (Liang et al., 2020). At the intersection of globalization and digitalization, understanding how the digital economy can address urban-rural duality and achieve regional integration has become a prominent topic for scholars and policymakers alike.

Guangxi, an important province in western China, demonstrates

notable regional disparities in economic development. Despite having certain resource advantages, such as its strategic location adjacent to ASEAN countries and abundant agricultural resources, the region has long struggled with weak economic foundations, inadequate transportation infrastructure, and significant urban-rural development gaps (Xu & Chen, 2021). Traditional economic models in Guangxi are predominantly characterized by smallholder farming with short industrial chains and low added value, exacerbating the income and development gaps between urban and rural areas (Yang & Zhang, 2022). With the increasing penetration of digital technology into agriculture, logistics, and public services, Guangxi has begun leveraging digital tools to optimize resource distribution and promote coordinated economic growth between urban and rural areas (Wang et al., 2022). Therefore, studying the mechanisms and pathways through which the digital economy facilitates Guangxi's urban-rural integration holds strong practical significance.

At the same time, national policies have provided robust support for the role of the digital economy in driving urban-rural integration. The "14th Five-Year Plan" explicitly

emphasizes the use of digital technologies to promote urban-rural integration and accelerate the construction of a "Digital China" (National Development and Reform Commission, 2021). As a key hub for the Belt and Road Initiative and the China-ASEAN cooperation, Guangxi has made rapid progress in digital infrastructure, rural e-commerce, smart agriculture, and digital public service systems in recent years. However, challenges such as underdeveloped infrastructure, low penetration of digital skills, and an incomplete policy framework persist (Zhang et al., 2023). By examining Guangxi's practices and identifying bottlenecks in leveraging the digital economy for urban-rural integration, this study aims to provide targeted policy recommendations for local governments and offer a development model for other similar regions, thereby advancing China's overall urban-rural integration process.

The purpose of this study is to explore how the digital economy can drive urban-rural integration in Guangxi through pathways such as industrial upgrading, resource optimization, and digitalization of public services, thereby narrowing the urban-rural divide and achieving coordinated regional development (Liu & Wei, 2020). By analyzing the application models and outcomes of the digital economy in agriculture, manufacturing, services, and social governance, this research seeks to uncover how digital tools can promote efficient flow and integration of resources between urban and rural areas (Chen et al., 2023). Furthermore, this study focuses on Guangxi's specific context, identifying existing challenges and bottlenecks, and proposes targeted and actionable policy recommendations to support urban-rural coordinated development. Additionally, the study summarizes the transferable experiences of Guangxi, offering valuable insights for other underdeveloped regions seeking to advance their urban-rural integration efforts.

2. LITERATURE REVIEW

2.1 Digital Economy and Regional Economic Development

Scholars worldwide widely agree that the digital economy, as a result of the deep integration of information technology and economic activities, has become a critical factor influencing regional economic growth. Bresnahan and Trajtenberg (1995) emphasized that the widespread adoption of digital technologies significantly enhances productivity, reduces transaction costs, and facilitates the flow of resources across regions. These changes not only improve economic efficiency but also promote regional economic balance by enabling less-developed areas to access advanced technologies and markets. Similarly, Brynjolfsson and McAfee (2014) argue that digital technologies represent a new wave of innovation, fostering economic opportunities and transforming traditional

industries, thereby accelerating regional development.

In China, digital economy research has primarily focused on its role in narrowing development gaps between regions. Wang Xiaolu et al. (2019) analyzed the contribution of the digital economy to the coordinated development of China's regional economies, concluding that digitalization plays a crucial role in reducing urban-rural disparities. For instance, digital technologies enable rural regions to overcome geographical and infrastructural barriers, connecting them to broader markets and creating new employment opportunities. By facilitating access to modern agricultural practices, e-commerce platforms, and logistics networks, the digital economy boosts rural economic vitality and encourages sustainable development.

Further evidence highlights how the digital economy contributes to regional economic integration by fostering new forms of industrial organization. As digital platforms bridge supply chains across regions, they enhance cross-regional cooperation and facilitate the sharing of production resources, allowing underdeveloped areas to integrate into global economic systems. This structural transformation, driven by digital technologies, demonstrates their potential to shape a more inclusive economic landscape.

2.2 Theoretical Exploration of Urban-Rural Integration

Urban-rural integration aims to eliminate the dual economic structure between urban and rural areas, promoting the free flow and equitable exchange of resources such as labor, land, and capital. Lewis's (1954) dual-sector model posits that optimizing the allocation of these key factors between urban and rural regions is essential for achieving integration. His theory highlights the significance of industrial and technological advancements in absorbing surplus rural labor and narrowing the development gap.

More recent studies have expanded Lewis's framework by incorporating digital transformation as a means of addressing urban-rural disparities. Liu Zhibiao (2020) argues that digitalization offers innovative pathways for achieving urban-rural integration by breaking time-space barriers. The development of e-commerce, smart agriculture, and digital logistics facilitates the seamless flow of goods, information, and services, enabling rural areas to benefit from urban economic opportunities. For example, smart agriculture leverages IoT (Internet of Things) technologies and big data analytics to optimize farming practices, thus increasing rural productivity and income levels.

Moreover, urban-rural integration involves the institutional reform of land use, labor mobility, and public resource allocation. Long and Woods (2011) highlight the role of governance mechanisms in ensuring equitable development

between urban and rural regions. They argue that without supportive institutional frameworks, technological advancements alone cannot sustain integration. As a result, researchers emphasize that digital technologies must work in tandem with policy innovations to address structural inequalities, thereby promoting long-term economic and social cohesion.

2.3 Practical Research on the Role of the Digital Economy in Urban-Rural Integration

Numerous studies have examined practical cases of how the digital economy drives urban-rural integration. For instance, Zhejiang Province is often cited as a model for leveraging digital agriculture and rural e-commerce to boost rural economies and foster urban-rural synergy. E-commerce platforms like Alibaba's Rural Taobao have provided farmers with direct access to consumers, eliminating intermediaries and increasing agricultural product prices. Furthermore, smart agricultural technologies, such as precision farming and drone-based monitoring, have optimized agricultural yields and reduced operational costs. These advancements demonstrate how digital tools can transform rural economic structures and promote integration with urban markets.

In contrast, Guangxi remains in the early stages of exploring the digital economy's potential to enhance urban-rural integration. Existing studies on Guangxi primarily focus on the direct impact of digital infrastructure development on economic growth, such as the expansion of broadband networks and mobile internet penetration. However, they often overlook the mechanisms and pathways through which digital technologies can bridge the urban-rural divide. For example, while Guangxi has made progress in building rural e-commerce platforms, issues such as inadequate logistics systems and insufficient digital literacy among rural populations continue to hinder its effectiveness.

A case study from Zhejiang highlights the importance of holistic ecosystem development, including investments in infrastructure, capacity building, and supportive policies. Scholars such as Huang and Xu (2022) argue that Guangxi could draw lessons from Zhejiang's experience by focusing on creating a comprehensive digital ecosystem that integrates agricultural production, processing, and distribution. Additionally, international practices, such as India's Digital India initiative, suggest that prioritizing digital skills training and community-based digital innovation can accelerate rural adoption of digital tools. These insights underscore the need for Guangxi to move beyond infrastructure investment and adopt a more integrated approach to leverage digital technologies for

urban-rural integration effectively.

The literature review reveals that significant progress has been made in understanding the role of the digital economy in promoting regional economic development, facilitating urban-rural integration, and exploring practical application pathways. Digital technologies, as crucial tools for improving productivity, optimizing resource allocation, and fostering the flow of key factors, provide both theoretical support and practical evidence for addressing the urban-rural dual structure. However, existing studies are predominantly focused on successful cases in economically developed regions and the direct effects of digital infrastructure development. There is a relative lack of research on how less-developed regions can leverage the digital economy to achieve urban-rural integration in line with their specific conditions. Additionally, while some studies discuss the application of digital technologies in agriculture, logistics, and public services, there is still a gap in understanding how to establish long-term mechanisms for optimizing governance structures and building sustainable digital ecosystems.

This study takes Guangxi as a case study, leveraging its unique context as a less-developed region to explore the specific mechanisms and pathways through which the digital economy can drive urban-rural integration. Building on existing literature, the research aims to fill gaps by addressing the practical challenges faced by less-developed regions and providing both theoretical insights and empirical evidence. Furthermore, by summarizing advanced practices from both domestic and international contexts, and integrating these with Guangxi's regional characteristics and policy environment, this study seeks to propose targeted recommendations. Ultimately, the research aspires to offer replicable models and pathways for other underdeveloped regions aiming to harness the digital economy for urban-rural integration.

3. RESEARCH METHODOLOGY

3.1 Qualitative Research Methods

This study employs qualitative research methods, including literature analysis, case studies, and comparative analysis, to explore how the digital economy drives urban-rural integration in Guangxi. These methods allow for a detailed examination of theoretical frameworks, real-world applications, and the mechanisms underlying digital transformation in less-developed regions.

The literature analysis provides a foundation for understanding the interplay between digital technologies and regional development. By reviewing academic articles, policy documents, and industry reports, this research identifies key concepts and debates related to digital economy strategies and

their impact on urban-rural integration. Theoretical models such as Lewis's dual-sector theory and frameworks on digital governance offer insights into the structural barriers that digital technologies can address.

Case studies of specific digital initiatives in Guangxi are crucial for capturing the region's unique challenges and opportunities. These include analyses of rural e-commerce platforms, smart agricultural projects, and digital public service delivery systems. Through these cases, the study examines how local contexts shape the adoption and outcomes of digital technologies. For example, Guangxi's experience with integrating e-commerce into rural supply chains provides a lens for understanding the transformative potential of digital tools in regions with limited infrastructure.

To broaden the understanding of best practices, the study also adopts a comparative analysis approach. By juxtaposing Guangxi's experiences with those of regions like Zhejiang Province, known for its advanced digital economy, or international examples such as South Korea's smart rural development projects, the research identifies successful models and lessons that can inform Guangxi's development. This approach also highlights the adaptability of different strategies in varying regional contexts.

The qualitative methods collectively focus on three critical aspects of urban-rural integration: the role of the digital economy in industrial upgrading, the diffusion of digital technologies between urban and rural areas, and the effectiveness of Guangxi's policy frameworks. This multi-dimensional perspective ensures a comprehensive analysis, bridging theoretical insights and practical implications.

3.2 Data Sources and Scope of Research

The study draws on a wide range of data sources to ensure its findings are both accurate and contextually relevant. Government statistical reports, academic research, case study documentation, and stakeholder interviews are integrated to construct a holistic view of Guangxi's current status and potential pathways for urban-rural integration.

Official statistical data is pivotal in mapping Guangxi's digital economy landscape. Reports from the National Bureau of Statistics, Guangxi's local government, and other agencies provide essential metrics, such as internet penetration rates, rural economic output, and public service accessibility. These quantitative insights help to identify regional disparities and measure the effectiveness of existing digital initiatives.

Academic literature enriches the analysis by providing theoretical frameworks and empirical evidence. Research on topics such as digital governance, rural e-commerce, and smart agriculture helps contextualize Guangxi's experience within broader national and international trends. For instance, studies

on how digital technologies enhance rural productivity and access to markets inform the evaluation of Guangxi's rural development strategies.

Regional case studies and local media reports offer practical perspectives on how policies and initiatives are implemented on the ground. Stories of success and challenges from rural e-commerce enterprises or smart farming cooperatives illustrate the tangible impacts of digital technologies. These examples are complemented by media coverage, which often highlights emerging issues, such as logistics bottlenecks or gaps in digital literacy among rural populations.

Stakeholder interviews provide qualitative insights that go beyond what is available in secondary data. Interviews with rural entrepreneurs, government officials, and community leaders shed light on the lived experiences of digital economy participants. These discussions reveal the barriers to technology adoption and the social and economic changes resulting from digital interventions.

This study focuses specifically on Guangxi while drawing on comparisons from other regions to enrich the analysis. Key sectors such as agriculture, logistics, healthcare, and education are examined to understand how digital technologies are transforming traditional urban-rural dynamics. By focusing on both sectoral and systemic issues, the research ensures a thorough exploration of Guangxi's unique context while identifying scalable lessons for other underdeveloped regions. By combining literature analysis, case studies, and comparative approaches, supported by diverse data sources, this study aims to offer a nuanced and actionable understanding of how the digital economy can facilitate urban-rural integration. The methods ensure that the analysis remains rooted in empirical realities while contributing to broader theoretical and policy debates.

4. FINDINGS

4.1 Digital Infrastructure Development and Urban-Rural Information Sharing

Digital infrastructure development has been a cornerstone of Guangxi's efforts to bridge the urban-rural divide, with the "Digital Countryside" initiative leading to transformative changes in connectivity across the region. Fiber-optic network coverage has expanded rapidly, reaching 98% of administrative villages by the end of 2023, compared to 65% in 2018. This significant improvement has provided a solid foundation for enabling rural communities to engage with the digital economy and access essential services. Table 1 highlights the steady progress in both fiber-optic coverage and rural internet penetration, which rose from 60% in 2018 to 85% in 2023.

Table 1: Guangxi Digital Infrastructure Development (2018-2023)

Year	Fiber Optic Coverage (%)	Rural Internet Penetration (%)
2018	65	60
2019	75	68
2020	82	74
2021	90	78
2022	95	82
2023	98	85

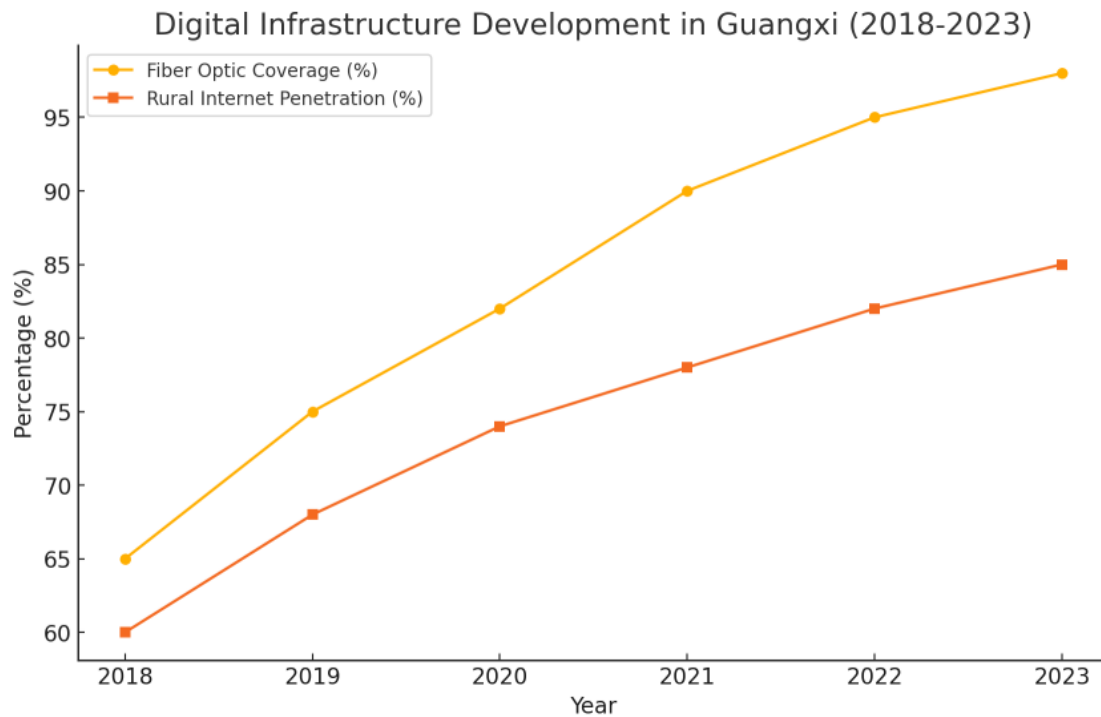
The expansion of fiber-optic networks has facilitated the integration of rural areas into broader economic systems. Rural businesses, for example, now have access to high-speed internet, enabling them to participate in e-commerce, access digital payment systems, and connect with urban markets. For instance, farmers can now receive real-time updates on market prices and weather conditions, which has significantly improved productivity and decision-making. Such advancements demonstrate how digital infrastructure directly contributes to economic empowerment in rural areas.

Improved connectivity has also enabled the dissemination of information and public services to previously underserved regions. Telemedicine and online education platforms have

become accessible to rural residents, addressing longstanding inequities in healthcare and education. This is particularly important for Guangxi, where many remote villages are geographically isolated. With better connectivity, these villages can now receive the same level of services as urban areas, reducing disparities in living standards.

Despite these achievements, a digital divide persists between rural and urban areas. While rural internet penetration has improved significantly, urban regions maintain penetration rates exceeding 95%, as shown in Chart 1. This gap highlights the challenges of achieving truly equitable access to digital infrastructure, particularly in Guangxi's remote and mountainous areas. These disparities limit the full participation of rural residents in the digital economy.

Figure 1: Digital Infrastructure Development in Guangxi (2018-2023)



Note: Shows trends in fiber-optic coverage and rural internet penetration.

Another challenge lies in the affordability of internet services and digital devices for rural households. While the infrastructure may be in place, the cost of accessing these services remains a barrier for many low-income families. Efforts to subsidize internet services and provide affordable devices will be essential to ensuring that digital infrastructure reaches its full potential in promoting inclusivity.

Furthermore, the uneven quality of internet services in rural areas presents another obstacle. Although fiber-optic networks have been extended to the majority of administrative villages, the speed and reliability of connections in remote regions are often inferior to those in urban centers. This inconsistency affects the usability of digital platforms and reduces the effectiveness of online services in rural areas.

To address these challenges, Guangxi must adopt a multi-faceted approach. First, the government should continue investing in expanding digital infrastructure to the most remote areas. Second, targeted subsidies and financial incentives should be provided to make digital access more affordable for rural households. Finally, upgrading the quality of internet services in rural areas, including improving speed and reliability, will be crucial for maximizing the benefits of digital connectivity.

In a nutshell, Guangxi's progress in digital infrastructure

development has been remarkable, enabling significant strides in urban-rural information sharing. However, persistent gaps in access, affordability, and service quality must be addressed to fully leverage the potential of digital infrastructure in promoting urban-rural integration. With targeted policies and sustained investment, Guangxi can ensure that digital infrastructure serves as a true equalizer across the urban-rural spectrum.

4.2 Rural E-commerce Driving Agricultural Upgrading

Rural e-commerce has emerged as a transformative force in Guangxi's agricultural sector, connecting farmers directly with consumers and bypassing traditional intermediaries. This digital transformation has significantly enhanced the profitability and efficiency of agricultural production. The revenue generated by rural e-commerce in Guangxi has seen exponential growth, increasing from 5 billion yuan in 2018 to 16 billion yuan in 2022, as shown in Table 2. This growth highlights the increasing reliance of rural producers on digital platforms to reach wider markets and adapt to the demands of modern consumers.

Table 2: Rural E-commerce Revenue in Guangxi (2018-2022)

Year	E-commerce Revenue (Billion Yuan)
2018	5
2019	7.5
2020	10
2021	13
2022	16

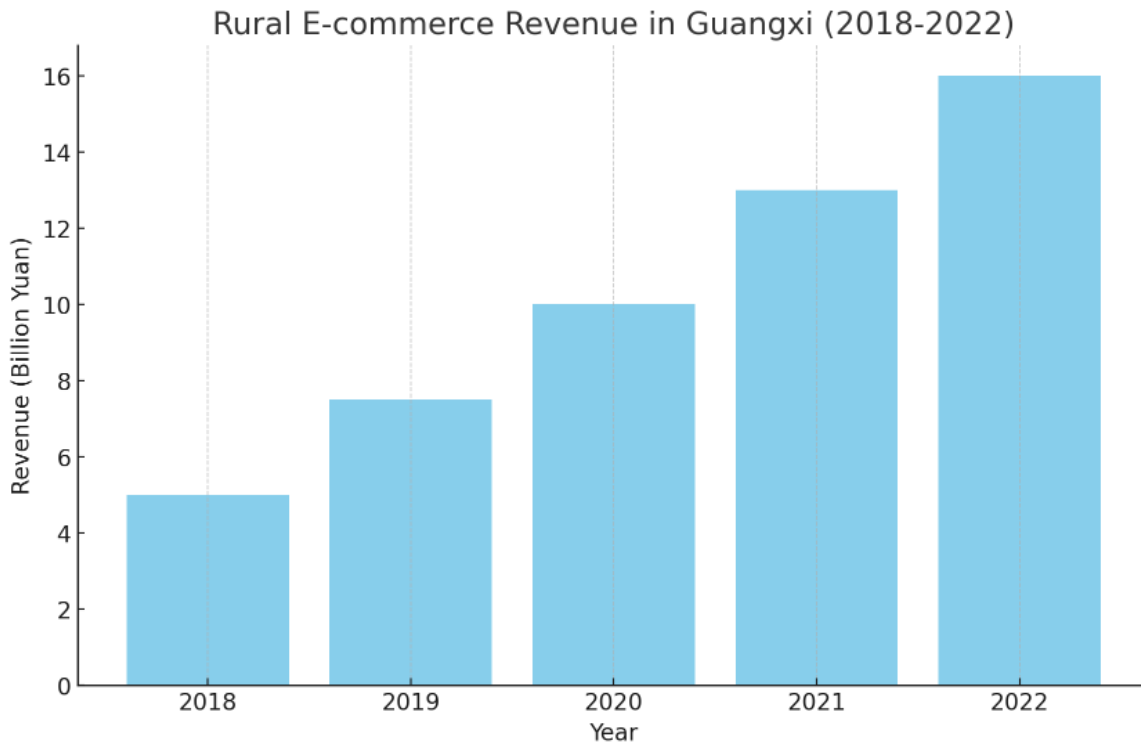
The development of rural e-commerce has facilitated agricultural upgrading in several key ways. First, it has improved market access for farmers, enabling them to sell their products beyond local and regional boundaries. For example, Guilin's tangerine farmers have leveraged e-commerce platforms to reach urban consumers across China, significantly increasing their profit margins. Similarly, Yulin's pig farmers have utilized online platforms to streamline sales and enhance product traceability, which is crucial for building consumer trust and securing higher prices.

Second, rural e-commerce has reduced the role of intermediaries, who traditionally consume a significant portion of the profits. By connecting directly with consumers through platforms such as Pinduoduo and Taobao Rural, farmers can

negotiate better prices and maintain greater control over their supply chains. This streamlined process not only enhances efficiency but also ensures that a larger share of the value generated remains with the producers.

Third, the digitalization of agricultural supply chains has improved transparency and efficiency. Digital platforms allow farmers to monitor market trends, manage inventory, and forecast demand more accurately. For example, smart logistics systems integrated with e-commerce platforms enable real-time tracking of goods, ensuring timely delivery and reducing wastage. These advancements are particularly beneficial for perishable goods like fruits and vegetables, which form a significant part of Guangxi's agricultural exports.

Figure 2: Rural E-commerce Revenue in Guangxi (2018-2022)



Note: Illustrates the steady growth of rural e-commerce revenue, reflecting its increasing economic significance.

Despite these achievements, rural e-commerce in Guangxi faces several challenges. One major obstacle is the underdeveloped logistics infrastructure in remote areas, which increases transportation costs and delays delivery times. For instance, some rural producers struggle to meet the growing demand for fresh agricultural products due to the lack of cold chain facilities. Addressing these logistical bottlenecks is essential for sustaining the growth of rural e-commerce.

Another challenge lies in the digital literacy of rural residents. While younger farmers are often quick to adopt e-commerce platforms, older generations may lack the skills and confidence to navigate these technologies. This digital divide limits the participation of certain groups in the digital economy. Training programs aimed at building digital skills among farmers can play a critical role in bridging this gap.

Furthermore, ensuring consistent product quality remains a pressing issue. As rural producers scale up their operations to meet increasing demand, maintaining high standards of quality and safety becomes more challenging. Implementing quality assurance mechanisms and certification systems can help build consumer trust and enhance the reputation of Guangxi's agricultural products in the digital marketplace.

In conclusion, rural e-commerce has become a powerful driver of agricultural upgrading in Guangxi, enabling farmers to access broader markets, increase profitability, and modernize their practices. However, to fully harness its potential,

challenges related to logistics, digital literacy, and quality control must be addressed. With continued investment in infrastructure and targeted support for farmers, rural e-commerce can serve as a cornerstone of sustainable development in Guangxi's agricultural sector.

4.3 Digital Technology Advancing Equitable Public Services

Digital technology has played a pivotal role in bridging the urban-rural divide in access to essential public services such as healthcare and education in Guangxi. Through initiatives like telemedicine and cloud-based education platforms, rural communities are experiencing a significant improvement in the quality and accessibility of these services, which were previously limited by geographic and resource constraints.

One of the most impactful applications of digital technology has been in the healthcare sector. Telemedicine networks have expanded rapidly in Guangxi, connecting over 200 rural health centers with urban hospitals by 2023. These networks enable patients in remote areas to consult with specialists in urban hospitals through video conferencing and other digital tools. This has significantly reduced the need for costly and time-consuming travel to urban centers, ensuring that rural residents receive timely and high-quality medical care. For example,

rural health centers equipped with telemedicine facilities reported a 40% increase in patient consultations in 2023 compared to 2018.

Additionally, digital technology has facilitated the sharing of medical expertise and resources. Urban hospitals now provide remote training to rural healthcare workers, improving their skills and knowledge. Advanced diagnostic tools, such as AI-powered imaging systems, have been integrated into rural health centers, enabling accurate and efficient diagnoses. These innovations have not only improved patient outcomes but also strengthened the overall healthcare system in rural areas.

In the field of education, digital platforms like Guangxi's "Cloud Classroom" have revolutionized learning opportunities for rural students. By 2023, the platform had reached over

50,000 students in remote areas, providing them with access to high-quality teaching resources previously available only in urban schools. Teachers in rural schools now have access to standardized curricula, interactive teaching materials, and online training programs, enhancing the overall quality of education. This has been particularly beneficial in bridging the learning gap between urban and rural students.

However, disparities persist. Internet access remains a significant barrier to equitable public service delivery in rural areas. As shown in Table 3, the internet penetration rate in underdeveloped areas of Guangxi is only 60%, compared to 98% in developed regions. This digital divide limits the reach and impact of telemedicine and online education initiatives, particularly in the most remote and underserved communities.

Table 3: Internet Access Disparities in Guangxi by Region (2023)

Region	Internet Access Rate (%)
Developed Areas	98
Underdeveloped Areas	60

Affordability is another challenge. While platforms like telemedicine and cloud classrooms are technically accessible, the cost of necessary devices and data plans can be prohibitive for low-income households. Many rural families still lack the financial means to purchase smartphones, tablets, or computers required to participate fully in these digital services. Addressing these affordability issues is critical to ensuring that all residents can benefit equally from the opportunities created by digital technology.

Moreover, digital literacy remains a significant hurdle. While younger generations are generally more adept at using digital tools, older residents and those with limited formal education often struggle to navigate these platforms. This limits their ability to access online healthcare services or support their children's participation in online learning. Government-led digital literacy programs are essential to overcoming these barriers and ensuring widespread adoption of digital public services.

To address these challenges, Guangxi needs to prioritize infrastructure development in underdeveloped areas, including expanding broadband access and improving internet speeds. Subsidies for devices and internet access for low-income families could also play a key role in making digital services more affordable. Furthermore, targeted training programs aimed at improving digital literacy among rural residents should be implemented to maximize the benefits of these initiatives.

Digital technology has significantly enhanced the accessibility and quality of public services in Guangxi's rural areas,

particularly in healthcare and education. However, to ensure equitable access, persistent barriers such as internet availability, affordability, and digital literacy must be addressed. By investing in infrastructure, providing financial support, and fostering digital skills, Guangxi can create a more inclusive environment where all residents can benefit from advancements in digital public services.

4.4 Digital Governance Enhancing Urban-Rural Coordination

Digital governance has become a critical tool for improving resource allocation and coordination between urban and rural areas in Guangxi. The integration of digital platforms into governance systems has enabled more efficient management of public resources, real-time decision-making, and enhanced service delivery, contributing significantly to urban-rural integration.

One notable example of digital governance is the implementation of a smart urban management platform in Beihai. This platform integrates data from both urban and rural areas to optimize waste management processes, including garbage collection and recycling. By leveraging IoT sensors and real-time analytics, the system has reduced operational costs by 25% and improved recycling rates in both urban and rural areas. Such innovations demonstrate how digital tools can enhance coordination and promote environmental sustainability across the urban-rural divide.

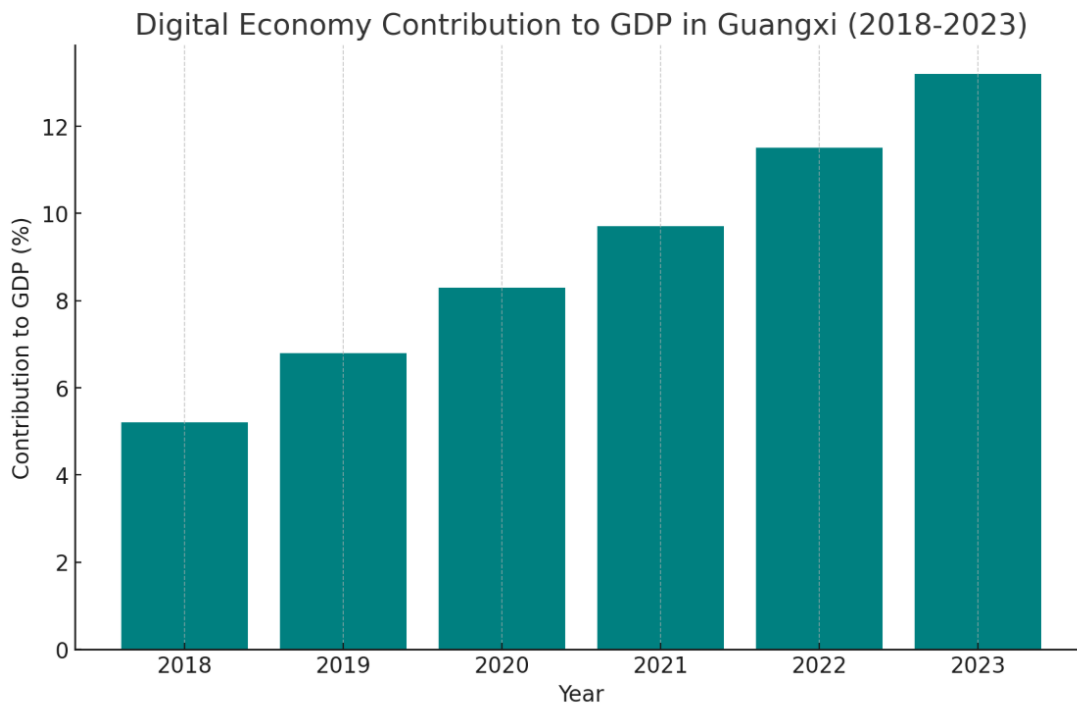
Another successful application of digital governance can be

seen in Nanning's intelligent transportation system. This system dynamically adjusts bus routes and schedules based on real-time demand, ensuring that rural residents have better access to urban centers. The system has increased rural ridership by 18% while reducing travel times by 12%, making public transport more efficient and accessible for all residents. These initiatives highlight the potential of digital governance to improve the quality of life and mobility for both urban and rural

populations.

The growing importance of digital governance in Guangxi is reflected in its contribution to the region's economy. As shown in Chart 4, the contribution of the digital economy to Guangxi's GDP has grown steadily from 5.2% in 2018 to 13.2% in 2023. This increase underscores the role of digital governance in driving economic development and fostering urban-rural integration.

Figure 3: Digital Economy Contribution to GDP in Guangxi (2018-2023)



Note: Illustrates the growing economic significance of digital governance and the digital economy.

Despite these advancements, challenges remain. One significant barrier is the uneven distribution of digital governance systems across Guangxi. While cities like Beihai and Nanning have implemented advanced platforms, many rural areas lack the infrastructure and technical expertise needed to adopt similar systems. Bridging this gap will require targeted investments in digital infrastructure and capacity-building initiatives for local governments in rural areas.

Data privacy and security concerns also pose challenges to the widespread adoption of digital governance. With the increasing use of personal data for decision-making and service delivery, ensuring robust cybersecurity measures and transparent data policies is crucial. Addressing these concerns will be essential to building public trust in digital governance systems.

To further enhance urban-rural coordination, Guangxi should focus on expanding the reach of digital governance platforms

to all regions, including its most remote areas. This could involve establishing regional digital hubs that provide technical support and resources to local governments. Additionally, investing in training programs for government officials and community leaders will help build the capacity needed to manage and sustain these systems effectively.

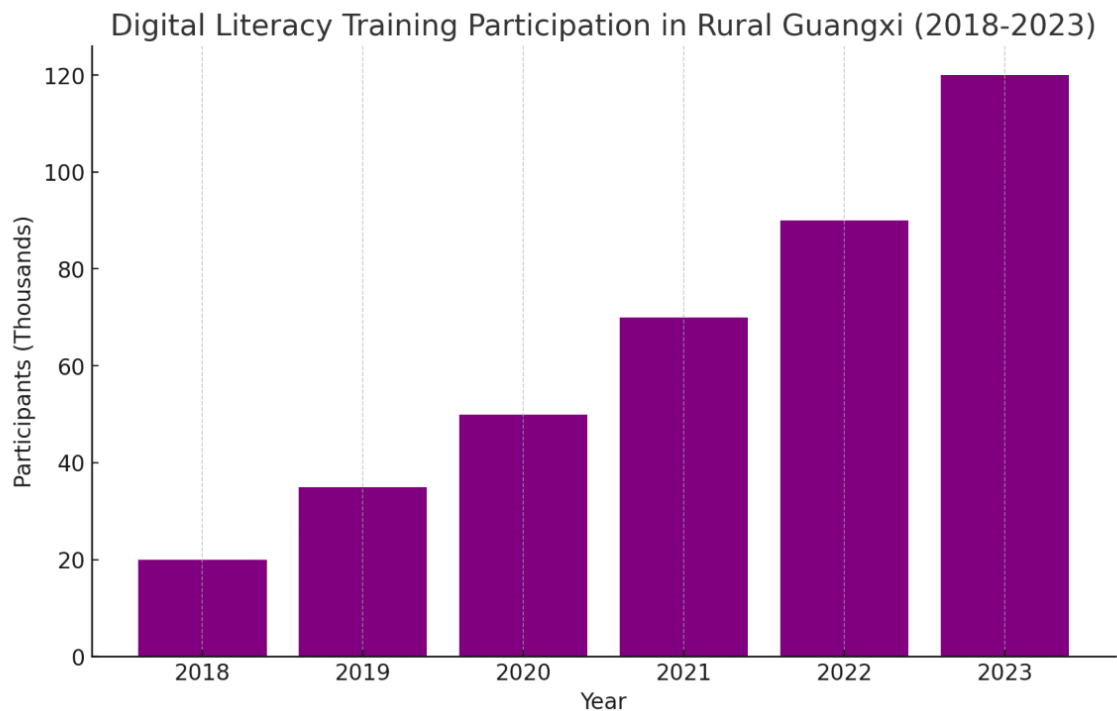
In conclusion, digital governance has proven to be a powerful tool for promoting urban-rural integration in Guangxi. By streamlining resource allocation and improving service delivery, these systems contribute to economic growth and social equity. However, to maximize their impact, Guangxi must address challenges related to infrastructure, technical expertise, and data security. With strategic investments and policy interventions, digital governance can play an even greater role in fostering sustainable and inclusive development across the region.

4.5 Persistent Challenges of Digital Inequality

Despite significant progress in Guangxi's digital infrastructure and governance systems, digital inequality remains a persistent challenge that limits the full potential of urban-rural integration. Digital inequality manifests in two key dimensions: access to technology and the ability to effectively utilize digital tools. While digital infrastructure has expanded significantly, as shown in previous sections, barriers such as affordability, literacy, and geographic disparities continue to hinder equitable participation in the digital economy.

One critical aspect of digital inequality is the disparity in digital literacy between urban and rural residents. Although Guangxi has made considerable efforts to provide training programs, as illustrated in Chart 5, the number of participants in digital literacy training programs in rural Guangxi increased from 20,000 in 2018 to 120,000 in 2023. While this growth is encouraging, the demand for such training still far exceeds supply, and a large portion of the rural population remains digitally illiterate. Older residents, in particular, face difficulties in adopting digital tools due to limited exposure and educational constraints.

Figure 4: Digital Literacy Training Participation in Rural Guangxi (2018-2023)



Note: Depicts the steady increase in participation, highlighting ongoing efforts but also unmet needs.

Additionally, affordability remains a significant barrier. Although infrastructure has improved, many rural households struggle to afford smartphones, tablets, or computers, as well as data plans and broadband subscriptions. This economic barrier disproportionately affects low-income families, preventing them from accessing digital services such as e-commerce, online education, and telemedicine. Without targeted subsidies or financial support, these households risk being excluded from the benefits of the digital economy.

Geographic disparities also exacerbate digital inequality. As highlighted in section 4.3, internet penetration in underdeveloped regions of Guangxi remains significantly lower than in developed areas (60% versus 98% in 2023). Remote and mountainous areas often lack the same quality of internet

services as urban centers, with slower speeds and less reliable connections. These disparities limit the effectiveness of digital platforms and hinder the integration of these regions into broader economic and social systems.

Another key challenge is the gap in digital skills among rural residents. While younger generations are generally more adept at using digital tools, older residents and less-educated individuals often struggle to navigate platforms such as online marketplaces or e-government services. This divide not only restricts their participation in the digital economy but also limits their access to essential services.

To address these challenges, Guangxi must adopt a multi-pronged strategy. First, targeted digital literacy programs should be scaled up, focusing on vulnerable groups such as

older adults and low-income families. These programs should prioritize practical skills, such as using mobile payment systems, accessing online education resources, and engaging in e-commerce activities. Second, financial support mechanisms, such as subsidies for devices and internet access, should be implemented to ensure affordability. Third, the government should invest in enhancing internet quality in remote regions, particularly through partnerships with private telecom providers.

Moreover, community-based initiatives can play a significant role in bridging the digital divide. For instance, setting up digital learning hubs in rural areas, equipped with shared devices and internet access, can provide residents with hands-on experience and training. These hubs can also serve as centers for disseminating information about government programs and digital opportunities.

While Guangxi has made notable strides in digital development, persistent challenges related to digital inequality continue to impede progress toward urban-rural integration. Addressing these challenges will require a comprehensive approach that combines infrastructure development, digital literacy training, affordability measures, and community engagement. By tackling these barriers, Guangxi can ensure that all residents, regardless of location or socioeconomic status, can fully participate in and benefit from the digital economy.

5. DISCUSSION AND CONCLUSION

5.1 Mechanisms of the Digital Economy Driving Urban-Rural Integration

Research indicates that the digital economy profoundly influences urban-rural integration by reshaping production methods, transforming consumption patterns, and innovating governance mechanisms. First, digital technology significantly reduces transaction costs and facilitates the flow of resources. By breaking spatial limitations, digital platforms enable more efficient exchange of goods, services, and information between urban and rural areas. For example, e-commerce platforms allow rural products to directly enter urban markets while providing rural communities with access to high-quality urban goods at lower costs. This bidirectional flow not only reduces the economic distance between urban and rural regions but also invigorates rural economies.

Second, the digital economy enhances productivity through technological empowerment. In smart agriculture, many farmers in Guangxi now utilize IoT technologies and data analytics tools to optimize crop management, significantly improving agricultural productivity. These advancements not only minimize resource waste but also enhance the quality and competitiveness of agricultural products. Similarly, the digital

transformation of the service sector enables rural areas to enjoy more efficient and accessible services, such as mobile payment systems and digitalized logistics networks, injecting new vitality into rural economies. This boost in productivity facilitates the transition of rural areas from traditional resource-dependent economies to technology-driven economies.

Additionally, the digital economy plays a crucial role in optimizing public service delivery and promoting social equity. Digital technologies address rural areas' deficiencies in infrastructure and services, creating integrated public service systems that benefit both urban and rural residents. For example, telemedicine, online education, and e-government services in Guangxi have significantly improved access to essential services for rural populations. These technological advancements not only close the service gap but also enhance overall quality and equity, creating a more balanced society. In sum, the digital economy provides critical mechanisms that dismantle barriers between urban and rural areas, paving the way for sustainable integration.

5.2 Bottlenecks and Challenges in Guangxi's Digital Economy Development

Despite notable progress, Guangxi faces several challenges in leveraging the digital economy to promote urban-rural integration. The first challenge lies in insufficient policy implementation and a lack of targeted planning. While the government has introduced multiple policies supporting digital economic development, some regions lack clear development objectives and actionable roadmaps. In particular, resource allocation inefficiencies in remote rural areas have hindered the full realization of policy benefits. Moreover, local governments often lack the innovation necessary to create region-specific strategies, resulting in a gap between policy intentions and outcomes.

The second challenge is the scarcity of technical resources and skilled personnel, which constrains the potential of rural digital economic development. Many rural areas in Guangxi have low levels of digital technology adoption, particularly in sectors such as smart agriculture and rural e-commerce, where technical expertise is crucial. On one hand, the lack of grassroots technical personnel hampers the implementation of digital initiatives. On the other hand, rural residents often lack the digital skills needed to effectively utilize digital tools, further limiting the benefits of digitalization. Even in regions with adequate infrastructure, the shortage of human resources poses significant barriers to progress.

Lastly, disparities in digital infrastructure distribution remain a major obstacle. While fiber-optic network coverage has reached high levels across Guangxi, the quality of networks in remote and mountainous areas is still far behind urban regions. Poor

connectivity in these areas prevents residents from fully participating in the digital economy, perpetuating the digital divide between urban and rural populations. These infrastructural inequalities not only hinder the penetration of digital technologies into rural areas but also widen the gap in access to information and services.

5.3 Recommendations

To fully unlock the potential of the digital economy in driving urban-rural integration, Guangxi must adopt a multi-dimensional strategy. First, the government should continue to invest in digital infrastructure, particularly in impoverished and remote areas. By collaborating with telecommunications companies and offering subsidies or incentives, Guangxi can accelerate the deployment of networks and smart devices in underserved regions. Additionally, improving the quality and reliability of internet services in these areas is essential to ensuring equitable access to digital platforms.

Second, the development of human capital and digital skills must be prioritized. A multi-tiered training system should be established through collaboration between government agencies and private enterprises to provide tailored digital skills programs for rural residents. Such programs can teach practical skills, including e-commerce operations, smart farming practices, and the use of online public services. Additionally, attracting technical talent to rural areas through incentive programs can help address the shortage of expertise, creating a dual approach of “developing local talent” and “importing external expertise.”

Furthermore, Guangxi should optimize its policy framework to support regional collaboration and tailored strategies. Local governments must develop differentiated digital economy plans based on regional characteristics and resource endowments. For example, regions with strong agricultural advantages can focus on advancing smart agriculture and e-commerce, while remote mountainous areas might prioritize the digitalization of public

services. Additionally, regional collaboration mechanisms and data-sharing platforms should be established to enhance the efficient flow of resources and information between urban and rural areas.

Lastly, expanding the application scenarios of the digital economy is essential for driving deeper integration. Guangxi can further promote the adoption of smart agriculture, rural e-commerce, telemedicine, and online education to increase the penetration of digital technologies into industry and society. For instance, the use of smart farming techniques can optimize production and management processes, increasing agricultural output and value-added potential. Expanding rural e-commerce networks can provide more efficient distribution channels for agricultural products. Meanwhile, improving telemedicine systems can offer remote populations better healthcare services, and online education platforms can enhance learning opportunities for rural students.

In conclusion, while Guangxi has built a solid foundation for urban-rural integration through the digital economy, challenges such as policy gaps, talent shortages, and infrastructural disparities must be addressed. By focusing on infrastructure, human capital, policy coordination, and expanded application scenarios, Guangxi can overcome these obstacles and ensure inclusive and sustainable development. As digital economy initiatives continue to advance, Guangxi has the potential to serve as a model for other less-developed regions striving to achieve urban-rural integration.

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7. CONFLICT OF INTEREST STATEMENT

The author has no conflicts of interest to declare.

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