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The Green-Inclusive Paradox in the Digital Economy: Technological Progress, Sustainable Development, and Social Stratification

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Abstract:

While driving socioeconomic development, the digital economy is also having a profound impact on social inequality. Research shows that digital technology exacerbates social stratification through mechanisms such as skill-biased progress, platform monopolies, and the digital divide. This is manifested in several ways: skill premiums, technological displacement, and digital rent differentiation in income distribution; polarization trends, algorithmic control, and flexible employment inequality in the labor market structure; and disparities in digital access, capabilities, and resources in educational opportunities, which reinforce the intergenerational transmission of inequality. Empirical analyses indicate that while the digital economy may temporarily narrow income gaps through inclusive effects in the short term, its skill-biased nature and digital divide effects are likely to further exacerbate social stratification in the long run. Therefore, we should embed "inclusive digital development" at the core of sustainable transformation, ensuring the digital economy serves as an accelerator for the SDGs rather than a new engine of division.

Keywords: Digital Economy; Social Inequality; Technological Progress; Social Stratification

1. Introduction

Throughout the evolution of human society, technological progress has consistently been the driving force behind civilizational advancement. From the invention of the steam engine in the 18th century, which ushered in the First Industrial Revolution, to the application of electricity in the 19th century, which sparked the Second Industrial Revolution, and then to the emergence of computer technology in the 20th century, which led to the Third Industrial Revolution, each major technological breakthrough has profoundly reshaped human society's modes of production, economic structures, and social hierarchies.

At present, cutting-edge digital technologies centered on big data, artificial intelligence, and blockchain are deeply integrated and widely applied, permeating every corner of the socio-economic landscape. From corporate production and operational models to individual lifestyles and consumption patterns, all have been reshaped by digital technology. In the industrial sector, traditional manufacturing industries leverage big data to achieve precise production and quality control, while AI-enabled smart factories are gradually replacing labor-intensive production scenarios. In the service sector, online platforms leverage algorithmic recommendations to provide personalized services to consumers, with digital technologies deeply integrated into everything from e-commerce shopping to cultural and entertainment activities, driving the vigorous development of new industries, business models, and operational paradigms. Digital technologies have become the core engine driving economic growth and social transformation.

However, the social impacts of technological progress exhibit significant dualistic characteristics. On one hand, the development of the digital economy has significantly enhanced social production efficiency. Groups and enterprises with technological advantages, resource endowments, and the ability to adapt swiftly have risen rapidly, achieving significant value growth; on the other hand, technological change may exacerbate social inequality. In the production sector, automation technology has replaced a large number of routine jobs, putting mid-skilled workers at risk of unemployment; algorithmic recommendations may reinforce information silos, exacerbating the uneven distribution of educational resources; the network effects of digital platforms can easily create a "winner-takes-all" market structure, widening income gaps. Additionally, high-skilled positions in the digital industry often offer generous salaries, while low-skilled workers in traditional industries may face the risk of job displacement, stagnant or declining incomes; in the employment sector, the digital economy has spawned numerous new occupations, but these roles demand high skill levels, and different groups have varying abilities to access such employment opportunities. More concerning is that disparities in the application of digital technology are forming new social stratification mechanisms: high-skilled workers leverage digital capabilities to secure higher compensation, while low-skilled groups face the risk of job displacement; high-quality digital educational resources are concentrated among high-income households, potentially reinforcing the intergenerational transmission of educational inequality; and disparities in digital infrastructure between regions may exacerbate imbalances in urban-rural and regional development.

This study focuses on the impact of technological progress on social inequality during the development of the digital economy, using the distribution of income, employment, and educational opportunities as entry points to deeply reveal the transmission pathways and mechanisms through which the digital economy influences social stratification. In terms of research methodology, a research paradigm combining theoretical analysis with empirical analysis is employed, utilizing regional-level panel data or microdata to identify the causal effects of digital economic development on social inequality. This study not only contributes to expanding the theoretical framework of social stratification in the digital economy era but also provides scientific evidence for government departments to formulate digital skills training policies, optimize the layout of digital infrastructure, and improve the digital governance system. It holds significant theoretical value and practical significance for promoting the equitable sharing of technological dividends and advancing social fairness and justice.

The structure of this paper is as follows: Chapter 2 reviews the literature on the relationship between the digital economy and social inequality, pointing out the gaps and shortcomings in the current field of research. Chapter 3 constructs a theoretical analysis framework and explores in depth the internal mechanisms by which technological progress affects social stratification. Chapter 4 empirically tests the relationship between the level of digital economic development and the degree of social inequality. Chapter 5 presents the conclusions.

2. Relevant Theory and Technical Foundations

2.1 The Development of Technological Progress Theory

Since the Industrial Revolution, the interactive relationship between technological progress and socio-economic structural changes has been a core topic of social science research. Marx's early theory of "machines displacing workers" pointed out that the widespread application of steam engines changed production methods, increased the organic composition of capital, intensified the opposition between capital and labor, and revealed the social contradictions inherent in technological progress. In the 20th century, Schumpeter's theory of "creative destruction" explained the dual impact of technological innovation on industrial structure from a dynamic evolutionary perspective: on the one hand, it releases development momentum by destroying old industrial systems, while on the other hand, it inevitably brings about employment shocks and income disparities as part of the transition process. With the rise of computer technology, research shifted to a skill premium perspective. In the 1980s, the wage gap between skilled and unskilled labor in the United States widened, prompting academia to focus on the skill-biased nature of

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technological change. Automation technology primarily replaces routine physical labor, while information technology significantly increases the demand for cognitive skills, providing a key theoretical clue for understanding social inequality in the digital economy era. Acemoglu and Autor (2011) proposed the theory of skill-biased technological progress, arguing that technological progress has a "task bias," prioritizing the replacement of labor performing routine tasks while maintaining or increasing demand for labor performing non-routine tasks, leading to "skill polarization" in the labor market [1]. Additionally, through "capital-skill complementarity," social inequality is exacerbated: technology-intensive industries drive up skill premiums, and the substitution effect increases unemployment risks for low-skilled workers, widening income gaps. The theory also emphasizes the regulatory role of the education system: when educational supply can promptly respond to new technology demands, it can mitigate the trend of worsening inequality; otherwise, it exacerbates skill mismatches and reinforces social stratification. In the digital economy era, the SBTC theory has been further expanded and refined. Digital technology not only continues the substitution effect on routine tasks but also widens income gaps through the premium on advanced cognitive skills. Acemoglu et al. (2022) point out that in regions with advanced digital economies, the digital skill premium has become the most important factor explaining income inequality, with explanatory power even surpassing traditional human capital factors [2].

2.2 Research on the Impact of the Digital Economy on Social Stratification

As the digital economy continues to develop, academic research on the relationship between technology and social inequality has witnessed a flourishing of theoretical innovation. Among these, the digital divide theory and platform capitalism theory stand out as the most explanatory analytical frameworks, offering a new theoretical perspective for understanding contemporary social stratification mechanisms. Van Dijk (2006) proposed the digital divide theory, which systematically deconstructs the social roots of technological inequality [3]. This theory examines four progressive dimensions—access, usage, skill, and outcome—to reveal how digital technology is embedded within existing social power structures and reinforces inequality. It argues that the digital divide is essentially a reflection of unequal distribution of social resources in the digital space, with marginalized groups facing multiple forms of exclusion leading to the cumulative worsening of "digital poverty." As the digital economy continues to develop, this theory has evolved into the concept of the "second-layer digital divide," emphasizing that even after widespread technological access, differences in advanced capabilities such as digital literacy and algorithmic understanding among different groups will still result in significant disparities in the empowering effects of technology. Zuboff (2019) revealed that platform companies systematically entrench the digital divide through carefully designed algorithmic architectures, with their surplus extraction mechanisms constituting a new form of digital exploitation [4].

Srnicek (2017) proposed the theory of platform capitalism, which highlights from the perspective of production relations that platform capitalism is not only a transformation of the economic form but also a profound restructuring of the social stratification mechanism [5]. Digital platforms have restructured the value distribution landscape through data colonization: platform companies monopolize data production resources, commodify user behavior data to achieve capital accumulation, while users, as data producers, find themselves trapped in a "digital proletarianization" dilemma. In the labor domain, platforms implement precise control through algorithmic black boxes, such as Uber's dynamic pricing algorithm, which turns drivers into "algorithmic dependents," leading to a sustained decline in actual hourly wages. This gig economy model evades social security responsibilities by blurring employment relationships, trapping people in an "algorithmic trap"—where high-intensity labor coexists with income instability, forming a new digital underclass.

The impact of the digital economy on social inequality is primarily manifested in three dimensions: income distribution, employment structure, and education. In terms of income distribution, on the one hand, the phenomenon of high-skill premiums has garnered significant attention. Highly skilled workers, who are proficient in digital technologies, can earn higher incomes, thereby exacerbating the degree of high-skill premium. On the other hand, the rapid development of the digital economy has led to an uneven distribution of digital dividends among different groups. Some groups can fully enjoy the benefits brought by the development of the digital economy, while others are marginalized. In terms of employment structure, the widespread application of digital technologies has led to significant changes in the skill requirements of the labor market, with a continuous increase in the demand for highly skilled workers. The digital economy has driven polarization in the job market, with increased demand for both high-skilled and low-skilled positions, while demand for mid-skilled positions has decreased. In the education dimension, there are significant disparities in access to and utilization of digital educational resources. While online education has provided more learning opportunities to some extent, it also poses risks of exacerbating educational inequality.

2.3 Literature Review

Existing research on the relationship between technological progress and social inequality has shown a clear trajectory of theoretical evolution and expansion of research perspectives, primarily manifested in the following three dimensions: First, theories of technological progress have evolved and deepened from Marx's revelation of the essence of social contradictions during the Industrial Revolution, to Schumpeter's analysis of the impact of technological innovation on industrial structure, and finally to the focus on the role of digital skill premiums in inequality in the digital economy era. Second, the impact of the digital economy on social stratification has introduced new perspectives. The digital divide theory reveals how digital technology is embedded in social structures and reinforces inequality, while the platform capitalism theory highlights how digital platforms are restructuring social stratification and creating issues related to the digital underclass. Third, the impact of the digital economy on social inequality is manifested in income distribution, employment structure, and education dimensions, leading to issues such as high-skill premiums, employment polarization, and disparities in digital educational resources. Although existing research has explored the relationship between technological progress, the digital economy, and social inequality from multiple angles, most studies have focused on single theories or analyses of specific dimensions, lacking in-depth exploration of the comprehensive application and interactive mechanisms of different theories in the context of the digital economy. This paper aims to integrate the theories of technological progress, the digital divide, and platform capitalism to systematically analyze how the digital economy influences social inequality through pathways such as technological transformation, resource allocation, and the restructuring of production relations, from the dimensions of income distribution, employment structure, and educational opportunities. It also explores effective strategies to mitigate social inequality, providing theoretical references and practical guidance for promoting social fairness in the digital economy era.

3. The Mechanism of Technological Progress on Social Stratification

This paper constructs a three-dimensional theoretical analysis framework of "technology-institution-capability" to integrate the core ideas of skill-biased technological progress theory, the digital divide theory, and platform capitalism theory. It reveals the transmission path of the digital economy's impact on social inequality from three key dimensions: income distribution, employment structure, and educational opportunities.

3.1 The Mechanism of Income Differentiation Driven by Digital Technology

Against the backdrop of rapid development in the digital economy, the impact of technological progress on income distribution has exhibited new characteristics and trends. The relatively stable income distribution pattern of the traditional industrial era is being reshaped by digital technology, giving rise to a more complex mechanism of income differentiation [6]. Specifically, this differentiation is primarily achieved through three mutually reinforcing pathways: First, the digital skill premium mechanism highlights the amplifying effect of human capital differences. The capital-skill complementary nature of digital technology enables highly skilled workers with digital skills to earn wages significantly higher than the market average. Second, the substitution effect of automation technology directly impacts low- and medium-skill jobs. In manufacturing and services, digital technologies such as robots and intelligent systems are replacing repetitive tasks, leaving workers in related fields facing unemployment or stagnant wages [7]. Finally, platform monopolies exacerbate structural imbalances in income distribution. Platform companies extract excessive profits through monopolizing user data, but these gains primarily flow to capital holders rather than workers, creating a new form of digital exploitation. The premium for digital skills widens the wage gap between skilled and unskilled workers, technological substitution compresses middle- and low-income positions, and the distribution of digital rents reinforces capital gains, collectively forming the driving force behind the sustained expansion of income disparities in the digital age. This polarization is not only reflected at the individual income level but also forms a distinct "digital divide" across industries and regions.

3.2 Digital Technology Reshapes the Employment Structure

The development of the digital economy has also led to structural changes in the job market. The rise of platform capitalism has altered traditional employment relationships and reshaped the entire social employment ecosystem, primarily manifesting in three dimensions: First, the phenomenon of employment polarization is becoming increasingly prominent. On one hand, the development of digital technology has created a large number of high-paying digital technology positions; on the other hand, digital technology has also generated numerous low-skill service positions. Meanwhile, traditional mid-skill positions are being rapidly replaced by automation technology [8]. This "expansion at both ends and contraction in the middle" of the employment structure is reshaping the social class distribution. Second, algorithmic control is restructuring labor relations. Platform companies use intelligent algo-

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rithmic systems to achieve detailed management of the labor process, trapping workers in a "digital Taylorism" dilemma: work rhythms are entirely dictated by algorithms, income volatility intensifies, and occupational autonomy is lost. The opaque rules of algorithms often lead to unfair treatment of workers [9]. Finally, flexible employment models introduce new risks. Digital platforms have successfully avoided employer responsibilities by transforming traditional employment relationships into task-oriented gig collaborations. While this shift has increased labor flexibility, it has also left workers facing issues such as lack of social security and obstacles to career development. Gig workers cannot enjoy stable welfare benefits nor access systematic skill training, leaving them trapped in a cycle of low-quality employment. Employment polarization has altered job structures, algorithmic control has reshaped the labor process, and flexible employment has restructured labor relations. These factors collectively exacerbate the complexity of employment inequality in the digital age.

3.3 The Digital Divide and Educational Inequality: Intergenerational Differentiation in the Digital Economy Era

The development of the digital economy has brought about profound changes in the distribution of educational opportunities. The widespread adoption of digital technology has not automatically led to educational equity; instead, it has exacerbated educational inequality through three key mechanisms, thereby reinforcing social stratification: First, the "first barrier" of digital access highlights foundational inequalities. Significant gaps exist between urban and rural areas, as well as among different income groups, in terms of access to digital devices and internet connectivity, directly affecting the ability to access learning opportunities [10]. Second, digital literacy drives social stratification. Access to education in advanced skills such as digital literacy and algorithmic understanding exhibits significant class disparities. Children from advantaged families often gain early exposure to digital skills like programming and data analysis through extracurricular training and family education, while children from disadvantaged families may struggle even with basic digital tool usage [11]. Finally, the "digital monopoly" of educational resources exacerbates social stratification. High-quality digital educational resources are increasingly concentrated among advantaged groups. The accumulation of "digital cultural capital" creates a Matthew effect: children from advantaged groups gain more development opportunities through digital education, while those from disadvantaged groups fall into a vicious cycle of "digital poverty." Access restrictions hinder skill development, insufficient skills limit resource access, and resource scarcity further solidifies social disparities.

The development of the digital economy, while driving efficiency gains and innovation, has also exacerbated social inequality across three dimensions: income, employment, and education. This structural divergence poses a severe challenge to the social inclusivity goals of sustainable development. Without effective policy intervention, digital technologies may further widen gaps between groups, leading to wasted human resources, insufficient domestic demand, and diminished social cohesion—all of which hinder coordinated economic, social, and environmental progress. Consequently, transforming technological dividends into more inclusive and sustainable drivers of social development to achieve genuine sustainable development remains a formidable challenge.

4. Empirical Design and Analysis

4.1 Empirical Design and Variable Definition

To explore the impact of digital economic development on income inequality, this paper constructs the following OLS regression model and double fixed-effects model:

$$IG_{it} = \alpha + \beta \times Dig_{it} + ?_{it}$$

$$IG_{it} = \alpha + \beta \times Dig_{it} + \mu_i + \lambda_t + ?_{it}$$

Where IG_{it} represents the explained variable, which is income disparity. Dig_i indicates the level of digital economic development. α is the intercept term of the model. β is the regression coefficient of the explained variable. $?_i$ is the random error term. μ_i represents the individual fixed effect of the i-th prefecture-level city, capturing all city-specific factors that do not change over time but may affect the urban-rural income gap (IG) or the development of digital inclusive finance (Dig). λ_t represents the time fixed effect of the t-th year, capturing all common time trends or external shocks faced by cities in a specific year.

The dependent variable is income gap (IG), measured by the ratio of per capita disposable income of urban residents to that of rural residents. The core explanatory variable is the level of digital economic development (Dig), measured by the digital inclusive finance index at the prefecture-level city level, which can precisely capture the transmission mechanism of the digital economy on urban-rural income gaps through the theory of financial inclusion. Table 1 presents the descriptive statistics of the variables. The mean value of the urban-rural income gap (IG) is 2.254, indicating that the average income of urban residents is 2.25 times that of rural residents, with a significant overall gap. The standard deviation of 0.419 indicates strong dispersion in regional differences, with some

cities approaching equality while others exhibit extreme disparities. The mean value of the digital inclusive finance index (Dig) is 215.385, indicating an overall level of upper-middle.

Table 1 variables descriptive statistics

	Obs	Mean	SD	Min	Max
IG	2816	2.254	0.419	0.480	3.970
Dig	2816	215.385	59.879	28.530	361.066

4.2. Empirical Results and Analysis

Table 2 reports the regression results of gradually introducing fixed effects to examine the impact of digital economic development (Dig) on income inequality (IG), showing a significant trend of change. The benchmark OLS regression in Column (1) shows that the coefficient of Dig is -0.002 and is significant at the 1% level, indicating that the digital economy generally has the effect of narrowing income inequality. Column (2) uses a panel regression model, where the coefficient remains unchanged but its significance is further enhanced, indicating that the inclusive effects of the digital economy are statistically reliable. However, in Column (3), after introducing time fixed effects, the direction of the Dig coefficient reverses, becoming 0.001 and significant at the 10% level. This suggests that after controlling for time trends, the impact of the digital economy on income inequality turns positive, implying that its long-term effects may differ fundamentally from short-term effects. Column (4), which controls for individual fixed effects, shows the coefficient returning to -0.002 and highly significant, indicating that regional heterogeneity plays a significant role in the relationship between the digital economy and income inequality. The most persuasive results come from the double fixed effects model in Column (5). After controlling for both time and individual effects, the Dig coefficient stabilizes at 0.001 and is significant at the 1% level, suggesting that the inclusive nature of the digital economy may narrow income gaps in the short term; however, in the long term, skill-biased technological progress and the digital divide effect will gradually emerge, enabling high-skilled groups to gain disproportionate benefits, ultimately exacerbating social stratification.

Table 2 Empirical Results

	(1)	(2)	(3)	(4)	(5)
	IG	IG	IG	IG	IG
Dig	-0.002***	-0.002***	0.001*	-0.002***	0.001***
	(-15.99)	(-44.45)	(1.65)	(-44.36)	(3.85)
Cons	2.689***	2.624***	2.363***	2.616***	2.310***
	(95.19)	(107.81)	(70.33)	(310.17)	(88.45)
Code	No	No	No	Yes	Yes
Time	No	No	Yes	No	Yes
N	2816	2816	2816	2816	2816
R^2	0.083			0.438	0.528

Note: t statistics in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The digital economy may contribute to promoting equality and inclusive growth in the short term, but it faces long-term tensions with social equity targets within the Sustainable Development Goals (SDGs). Without effective interventions targeting digital skills accessibility, regional balanced development, and welfare distribution systems, the structural differentiation effects of the digital economy will exacerbate social inequality and hinder the progress of sustainable and inclusive development.

5. Conclusion

The digital economy, as a key driver of contemporary socio-economic development, has had a profound impact on social inequality. While it has brought about efficiency gains, it has also given rise to new forms of inequality. The development of digital technology has gradually revealed the underlying mechanisms of skill-biased technological progress, platform monopolies, and the digital divide, which exacerbate social stratification. Specifically, this manifests as follows: in the income distribution di-

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mension, there is a digital skill premium, technological displacement, and the differentiation of digital rent distribution; in the employment structure dimension, there is a trend toward polarization, algorithmic control, and new forms of inequality through flexible employment; and in the education opportunity dimension, inequality is reinforced through the class differentiation of digital access, digital capabilities, and digital resources, leading to the intergenerational transmission of inequality. Empirical research indicates that the impact of digital economic development on social inequality exhibits significant dynamic characteristics and structural contradictions. While the digital economy may temporarily narrow income gaps through its inclusive nature in the short term, skill-biased technological progress and the digital divide effect will exacerbate social stratification in the long run.

If the digital dividend continues to concentrate at the top, it will simultaneously erode the three pillars of sustainable development: economic, social, and environmental. Skill premiums and digital rent differentials weaken macro-level consumption and human capital investment; class solidification reduces mobility and amplifies governance costs; while platform monopolies combined with high energy consumption in data centers hinder green innovation. Therefore, "inclusive digital development" must be embedded at the core of sustainable transformation: upgrading inclusive infrastructure with a green and low-carbon orientation, expanding value chain participation for vulnerable groups through diverse cooperative organizations, and achieving global synergy in data benefit sharing and symmetrical carbon responsibility. This will create a positive feedback loop among economic growth, green transition, and social justice, ensuring the digital economy serves as an accelerator for the SDGs rather than a driver of division.

This study expands the theory of social stratification in the digital economy era and provides scientific basis for government departments. Governments should take the following measures. First, strengthen digital skills training to enhance workers' skill levels and bridge the digital skills gap. Second, optimize the layout of digital infrastructure to improve digital access conditions in rural and remote areas, ensuring equitable digital opportunities. Third, improve the digital governance system to strengthen regulation of platform companies, prevent data monopolies and digital exploitation, and ensure fair distribution of benefits. Fourth, increase investment in education, particularly support for education for vulnerable groups, to narrow the gap in digital educational resources. Fifth, establish a labor protection mechanism adapted to the digital economy to safeguard the rights of gig workers and promote stability and fairness in the labor market. Future research could be advanced in the following directions: first, conduct longer-term tracking studies to capture the cumulative effects of digital inequality; second, strengthen cross-national comparative studies to analyze the heterogeneity of how digital technology influences social stratification under different institutional environments; third, explore new mechanisms through which emerging technologies like artificial intelligence impact social inequality.

References

[1] Acemoglu, D., & Autor, D. (2011). Lectures in labor economics. Manuscript. http://economics. mit. edu/files, 4689, 22.

[2] Acemoglu, D., Autor, D., Hazell, J., & Restrepo, P. (2022). Artificial intelligence and jobs: Evidence from online vacancies. Journal of Labor Economics, 40(S1), S293-S340.

[3] Van Dijk, T. A. (2006). Discourse, context and cognition. Discourse studies, 8(1), 159-177.

[4] Zuboff, S. (2019, January). Surveillance capitalism and the challenge of collective action. In New labor forum (Vol. 28, No. 1, pp. 10-29). Sage CA: Los Angeles, CA: Sage Publications.

[5] Srnicek, N. (2017). Platform capitalism. John Wiley & Sons.

[6] Autor, D. H. (2013). The "task approach" to labor markets: an overview. Journal for Labour Market Research, 46(3), 185-199.

[7] Autor, D. H., & Dorn, D. (2013). The growth of low-skill service jobs and the polarization of the US labor market. American economic review, 103(5), 1553-1597.

[8] Autor, D. H., Katz, L. F., & Kearney, M. S. (2006). The polarization of the US labor market. American economic review, 96(2), 189-194.

[9] Lu, Q. (2015). The end of polarization? Technological change and employment in the US labor market. Unpublished manuscript.

[10] Oldenski, L. (2014). Offshoring and the polarization of the US labor market. Ilr Review, 67(3_suppl), 734-761.

[11] Kim, J. (2025). Job Polarization within the Middle-Skill Group and Its Impact on Skills Mismatch. Three Essays on the Political Economy of Global Value Chains and Skills Governance, 6.