Impact of Digital Economy on China' s Economic Growth and Non-Agricultural Employment: An Input-Occupancy-Output Model Postprint

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Abstract

With the emergence of the digitalization wave, the digital economy will inevitably exert a more profound influence on China' s economy, manifested not only in promoting more rapid growth of Gross Domestic Product (GDP), but also in enhancing productivity, transforming consumption structures, optimizing investment structures, expanding enterprise export scales, improving human capital quality, and leading the development of new-type smart cities. This paper constructs a non-competitive employment input-occupancy-output model and employs the expenditure approach to GDP (i.e., the three aspects of final expenditure: consumption, total capital formation, and total exports) to calculate the economic scale of China' s digital economy, ultimately estimating the respective impact effects on employment generated by the economic scale formed by these three categories of expenditure. The study finds: (1) The integration of ICT (Information and Communications Technology) industries with traditional industries can drive the expansion of economic scale, particularly the growth of online consumption, and the resulting consumption-oriented employment effect is gradually expanding (causing the proportion of non-agricultural employment in total employment to increase from 15.2% in 2014 to 20.2% in 2016), with future development areas warranting special attention focusing on medical health, cultural entertainment, and transportation and communications. (2) The digital economy' s employment impact on technology-intensive manufacturing is stronger than on labor-intensive and capital-intensive manufacturing, while also demonstrating powerful employment effects in producer services, and promoting the transformation of China' s industrial economy from labor-intensive to technology-intensive. (3) China' s digital transformation will bring about productivity improvements and accelerated innovation, and promote the cultivation of vocational skills, driving the transformation of human capital from low-cost advantages to vocational skills advantages, thereby fostering a higher-skilled workforce.

Full Text

The Impact of Digital Economy on China' s Economic Growth and Non-Agricultural Employment–Based on an Input-Occupancy-Output Model

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Abstract

With the emergence of the digital technology wave, the digital economy will exert increasingly profound impacts on China' s economy, manifested not only in accelerating GDP growth but also in enhancing productivity, transforming consumption structures, optimizing investment patterns, expanding enterprise exports, improving human capital quality, and spearheading the development of new smart cities. This study constructs a non-competitive employment input-occupancy-output model to estimate China' s digital economy scale using the expenditure approach to GDP (encompassing three final expenditure categories: consumption, gross capital formation, and total exports), ultimately assessing how the economic scale generated by these three expenditure types affects employment. The findings reveal: (1) The integration of the information and communications technology (ICT) sector with traditional industries drives economic expansion, particularly through the growth of online consumption, whose resulting consumption-oriented employment effects are gradually intensifying (increasing the share of non-agricultural employment in total employment from 15.2% in 2014 to 20.2% in 2016). Future development should prioritize healthcare, cultural entertainment, and transportation/communication sectors. (2) The digital economy' s employment impact on technology-intensive manufacturing exceeds that on labor-intensive and capital-intensive industries, while also demonstrating strong employment effects in producer services, thereby facilitating China' s industrial transformation from labor-intensive to technology-intensive structures. (3) China' s digital transformation will enhance productivity and accelerate innovation, promote vocational skill development, and drive human capital transformation from low-cost advantages to vocational skill advantages, thereby cultivating a higher-skilled workforce.

Keywords: digital economy, economic growth, non-agricultural employment, input-occupancy-output model

1. Introduction

Driven by the rapid global development of information technology, the expansion and influence of the digital economy have attracted significant attention from nations worldwide. The United States, as a major birthplace of business model innovation, leads global trends in sharing economy, internet finance, e-commerce, and various other internet-based business models [1]. The United Kingdom regards big data development as a strategically significant initiative, focusing on digital government, e-commerce, smart cities, and cloud computing to ensure global leadership in digital economy development [2]. The Australian government views the digital economy as essential for boosting production, enhancing international competitiveness, and improving social welfare [3]. BRICS nations including Brazil, Russia, India, and South Africa have elevated internet technology and digital economy development to national strategic priorities [4]. China is currently implementing the "Cyberpower Strategy" to advance "Digital China" construction [5]. According to the "China Internet Development Report 2017" released at the Fourth World Internet Conference, China' s digital economy reached 22.58 trillion yuan in 2016, accounting for 30.3% of GDP. For China, the digital economy represents both a new variable for economic quality improvement and a new blue ocean for transformative growth.

The digital economy' s development profoundly impacts economic growth and employment. The China Internet Network Information Center (CNNIC) regularly publishes statistical indicators such as internet user numbers, domain names, IP addresses, and website counts through its China Internet Development Statistics Survey, providing a data foundation for measuring China' s internet development level [6-10]. The McKinsey Global Institute has developed the iGDP index, encompassing personal consumption, public expenditure, business investment in internet technology, and trade balances in internet-related goods and services [11]. Katz et al. (2010) measured broadband investment impacts on Germany' s economy and employment for two periods: 2014 and earlier, and 2015-2020, projecting 304,000 new jobs in the first phase and 237,000 in the second [12]. Rausas et al. (2011) found that by 2009, the internet economy had eliminated 500,000 jobs in France while creating 2.4 million new positions [13]. Behanm et al. (2012) demonstrated that ICT development had created 13 million jobs in Europe, representing 13% of total European employment [14]. Elsby and Shapiro (2012) noted that mobile communication technology upgrades from 2G to 3G and infrastructure development had created 1.585 million new jobs in the United States, with each 10% increase in 4G penetration generating 231,000 new jobs annually [15].

Domestically, Yu Xiaolong (2015) econometrically analyzed the positive employment effects of internet technology on China' s total employment and compared these effects with developed countries [16]. Wang Jun et al. (2017) elaborated on how technological progress represented by artificial intelligence impacts employment [17]. Niu Luqing (2017), Zhang Yingqiang and Zhang Jin (2017), and Ji Wenwen (2017) discussed research trajectories linking digital economy and employment from a digital economy perspective, presenting impact mechanisms but without empirical analysis [18-20]. From a comprehensive impact perspective, Long Haiquan et al. (2017) proposed a four-dimensional value space theory for virtual transactions by integrating network economy theory and strategic management theory, demonstrating how network resources affect enterprise value and competitive advantage [21]. Lin Hongwei and Shao Peiji (2014) studied optimal online advertising investment strategies for enterprises [22]. Luo Min and Li Liangyu (2015) argued that in the current digital economy era, traditional supply-oriented business models in value chains are gradually disappearing while demand-oriented internet business models and value creation are emerging [23]. Feng Hua and Chen Yaqi (2016) noted that in the internet environment, economic time-space connotations and extensions break through physical constraints, with positive externalities from network time-space spillovers enhancing economic efficiency [24]. Shi Bingzhan (2017) suggested that the internet as an information platform can reduce transaction costs, expand transaction scale, and optimize resource allocation [25]. Li Bing and Li Rou (2017) found through analysis of Chinese industrial enterprise export microdata that the internet significantly promotes enterprise exports, with effects similar to trade liberalization [26]. Liu Zhengchi et al. (2017) studied differentiated pricing for crowdfunding products using the internet crowdfunding model [27]. Sun Puyang et al. (2017) constructed a theoretical framework incorporating consumer heterogeneity in search and matching efficiency, finding that e-commerce platforms significantly impact retail market prices by effectively increasing consumer search frequency and reducing market search costs [28]. He Juxiang et al. (2015) calculated that China' s internet industry development level exhibits significant regional heterogeneity using 2003-2011 provincial panel data, with eastern coastal provinces demonstrating substantially stronger economic stimulation effects than western regions [29].

However, none of these studies specifically distinguish the core ICT industry within the digital economy or quantify and evaluate the digital economy' s value scale with proposed measurement methods. ICT and non-ICT industries exhibit substantial differences in technology, industrial, and trade structures, with digital and traditional economies also differing significantly in scale and structure. This paper establishes a non-competitive employment input-occupancy-output model reflecting digital economy characteristics that distinguishes between ICT and non-ICT industries, empirically compiling a 2012 non-competitive employment input-occupancy-output table that differentiates digital/traditional economies and ICT/non-ICT industries. From the perspective of differences between direct and complete value-added coefficients and employment coefficients, we measure the digital economy's impact on China's economic growth and non-agricultural employment from 2014 to 2016.

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2. Methodology

2.1 Non-Competitive Employment Input-Occupancy-Output Model Reflecting Digital Economy Characteristics This study develops a hybrid employment input-occupancy-output model incorporating digital economy features, improving upon the traditional non-competitive (import-distinguished) input-output model in three aspects: (1) All industrial sectors are classified as either ICT or traditional industries; (2) Final demand is divided into digital economy and traditional economy components; (3) Sector-specific employment matrices structured by age, education level, gender, and weekly working hours are incorporated. The improved model effectively captures how ICT and traditional industries differ in "employment coefficients per unit output, inter-sector consumption relationships, import shares in intermediate inputs, and final demand (consumption, investment, exports) scale and structure," thereby affecting value-added and employment in traditional sectors.

The specific formulation is shown in Table 1 , where superscript I denotes ICT industries (i = 1, 2, ···, k) and T denotes non-ICT industries (t = k+1, k+2, ···, n), with superscript M representing imports. Variable definitions are as follows: X^II, X^IT, X^TI, X^TT, M^II, M^IT, M^TI, M^TT are all n×n matrices (n = total industry classification count); X^II represents intermediate inputs from ICT to ICT industries; X^IT represents intermediate inputs from ICT to non-ICT industries; X^TI represents intermediate inputs from non-ICT to ICT industries; X^TT represents intermediate inputs from non-ICT to non-ICT industries; M^II and M^IT represent imported ICT products used as intermediate inputs to ICT and non-ICT industries respectively; M^TI and M^TT represent imported non-ICT products used as intermediate inputs to ICT and non-ICT industries respectively. Y^II, Y^TI, Y^IIM, Y^TIM are all n×s matrices (s = specific final demand categories including rural household consumption, urban household consumption, government consumption, fixed capital formation, inventory changes, and errors), representing domestic and imported ICT and non-ICT products used for digital economy final demand; Y^IT, Y^TT, Y^ITM, Y^TTM are similarly n×k matrices representing domestic and imported ICT and non-ICT products used for non-digital economy final demand; E^II and E^IT are k×1 column vectors representing ICT industry exports as digital and non-digital economy products; E^TI and E^TT are (n−k)×1 column vectors representing non-ICT industry exports as digital and non-digital economy products. X^I, X^T, M^I, M^T are all n×1 column vectors where X represents total output and M represents total imported products by industry; V^T and V^D are 1×n row vectors representing value-added for ICT and non-ICT industries; L^I and L^T are r×n matrices (r = employment structure categories, e.g., r=2 for gender, r=13 for age, r=7 for education) representing different types of employment in ICT and non-ICT industries.

2.2 Measurement of Digital Economy Impacts on Value-Added and Employment As shown in Table 1 , the non-competitive employment input-occupancy-output partial-closed model reflecting digital economy characteristics defines A^II, A^IT, A^TI, A^TT as direct consumption coefficient matrices for ICT-to-ICT, ICT-to-non-ICT, non-ICT-to-ICT, and non-ICT-to-non-ICT industries respectively. The following balance relationship holds:

$$\begin{bmatrix} X^I \\ X^T \end{bmatrix} = \begin{bmatrix} A^{II} & A^{IT} \\ A^{TI} & A^{TT} \end{bmatrix} \begin{bmatrix} X^I \\ X^T \end{bmatrix} + \begin{bmatrix} Y^I \\ Y^T \end{bmatrix}. \quad (1)$$

The corresponding Leontief inverse matrix is:

$$\begin{bmatrix} I - A^{II} & -A^{IT} \\ -A^{TI} & I - A^{TT} \end{bmatrix}^{-1} = \begin{bmatrix} B^{II} & B^{IT} \\ B^{TI} & B^{TT} \end{bmatrix}. \quad (2)$$

Where B^II, B^IT, B^TI, B^TT represent complete requirement coefficient matrices for ICT-to-ICT, ICT-to-non-ICT, non-ICT-to-ICT, and non-ICT-to-non-ICT industries respectively.

The influence coefficient and sensitivity coefficient are defined as:

$$\delta_j = \frac{\sum_{i=1}^{n} b_{ij}}{\frac{1}{n}\sum_{j=1}^{n}\sum_{i=1}^{n} b_{ij}}, \quad \theta_i = \frac{\sum_{j=1}^{n} b_{ij}}{\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} b_{ij}}.$$

Where _j represents the influence coefficient, reflecting the degree to which a unit increase in final demand for sector j affects all national economic sectors; _i represents the sensitivity coefficient, reflecting the degree to which sector i responds when all sectors increase final output by one unit. A larger influence coefficient indicates stronger pulling effects on other sectors—i.e., increased consumption, investment, and exports in that sector raise demand for products across sectors, driving overall economic development. A larger sensitivity coefficient indicates stronger supporting or bottleneck effects on other sectors, suggesting that coordinated national economic development requires greater development space for sectors with high sensitivity coefficients.

Define the direct employment coefficient for ICT industries as G^I = {g_j^I} = {l_j$^{I/x_j}$I} and for non-ICT industries as G^T = {g_j^T} = {l_j$^{T/x_j}$T}, where g_j represents employment per unit output in sector j. Complete employment in ICT and non-ICT industries to satisfy final demand can then be calculated as:

Define the direct value-added coefficient for ICT industries as AV^I = {Av_j^I} = {v_j$^{I/x_j}$I} and for non-ICT industries as AV^T = {Av_j^T} = {v_j$^{T/x_j}$T}, where Av_j represents value-added per unit output in sector j. Complete value-added for ICT and non-ICT industries to satisfy final demand can then be calculated as:

The impact of final demand on value-added can be divided into digital economy effects (TV^ID + TV^TD) and traditional economy effects (TV^IN + TV^TN), where TV^ID and TV^TD represent digital economy impacts on ICT and traditional industry value-added respectively, and TV^IN and TV^TN represent traditional economy impacts on ICT and non-ICT industry value-added respectively. Y^ID and Y^TD denote final demand for digital economy in ICT and traditional industries.

Similarly, final demand impacts on employment can be divided into digital economy effects (TG^ID + TG^TD) and traditional economy effects, where TG^ID and TG^TD represent digital economy impacts on ICT and traditional industry employment respectively. Due to inter-sector product interdependencies, differences in complete value-added and complete employment when satisfying digital versus traditional economy final demands are highly correlated with production technologies, industrial structures, direct value-added coefficients, direct employment coefficients, and demand structures across ICT and non-ICT industries. In other words, differential impacts of digital and traditional economies on value-added and employment stem from differences in production technologies, direct employment coefficients, direct value-added coefficients, industrial structures, and demand structures between ICT and non-ICT industries.

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3. Empirical Analysis of Digital Economy Impacts on Value-Added and Non-Agricultural Employment

3.1 Digital Economy Concept and Scale Measurement This paper defines the digital economy as encompassing all activities related to internet equipment production, service provision, and network applications. The base table is the "China 2012 Input-Output Table" published by the National Bureau of Statistics, with national economic sectors classified into ICT and non-ICT industries. Sectoral employment totals and structures for 2012 are obtained from the "China Economic Census Yearbook 2013" and "China Statistical Yearbook 2017." The input-output table's final demand component is then partitioned into digital and traditional economy scales, yielding a non-competitive input-output table reflecting digital economy characteristics.

Table 2 presents China's digital economy scale for 2014-2016, with consumption divided into three categories: basic equipment (software/hardware), online shopping, and other mobile app-driven consumption. Online shopping dominates, accounting for approximately 59% of total consumption, while mobile app-driven consumption accounts for about 20% (with online travel comprising a large share). Digital economy investment includes: (1) fixed capital formed by sectoral investment in ICT industries, and (2) fixed capital formed by ICT industry investment across sectors. Hardware sector fixed capital formed by cross-sectoral investment constitutes the main investment component in the digital economy, showing an annual growth rate exceeding 15% and indicating deepening integration between ICT industries and other sectors.

3.2 Measurement Results 3.2.1 Industrial Linkage Analysis of ICT Industries

Table 3 compares key indicators between ICT and non-ICT industries: direct employment coefficients, complete employment coefficients, direct value-added rates, complete value-added rates, influence coefficients, and sensitivity coefficients. ICT industries constitute important sectors, with final demand satisfied by ICT accounting for 15.7% of total final demand, while ICT total output represents 14.2% of national output—indicating that ICT output serves more as final products rather than intermediate inputs compared to non-ICT industries. Both direct and complete value-added rates in ICT industries exceed those in non-ICT industries, demonstrating that ICT industries create higher output with fewer intermediate inputs when considering upstream and downstream implicit value flows from a final demand perspective. While direct employment coefficients are similar between ICT and non-ICT industries, ICT industries generate substantially higher complete employment demand in non-ICT sectors than within their own sector, indicating that ICT development drives employment growth across other industries.

3.2.2 Digital Economy Impact on Value-Added Analysis

China' s digital economy scale as a share of GDP increased from 21.2% in 2014 to 24.1% in 2016 (a 3 percentage point increase), while digital economy-driven value-added as a share of GDP rose from 14.3% to 17.3% during the same period (Figure 1 [Figure 1: see original paper]). This demonstrates that the digital economy significantly enhances trade scale for ICT enterprises and differentiated products, thereby affecting trade benefits and patterns. Since value-added generated by imported intermediate inputs does not count toward China' s GDP, the digital economy' s value-added impact is smaller than the digital economy scale itself, indicating increasing reliance on imports in intermediate production processes and that the digital economy' s national economic impact increasingly depends on imported goods.

3.2.3 Digital Economy Impact on Non-Agricultural Employment Analysis

The digital economy' s vigorous development has not only accelerated GDP growth but also generated substantial employment effects. Model estimates indicate that the digital economy drove average annual growth of 15.32 million non-agricultural jobs, making it a primary driver of China' s non-agricultural employment growth. Moreover, this employment effect is expanding: digital economy-driven non-agricultural jobs increased from 82.85 million in 2014 to 113.5 million in 2016, raising its share of total non-agricultural employment from 15.2% to 20.2% (Figure 2 [Figure 2: see original paper]).

From an industrial structure perspective, the digital economy' s impact on secondary industry employment has increased annually from 18.7% in 2014 to 24.9% in 2016, with manufacturing employment accounting for 87.5% of digital economy-driven jobs in 2016, concentrated primarily in ICT industries (35.9% share). In 2016, digital economy-driven tertiary industry employment represented 50.9% of total non-agricultural jobs and 17.1% of total tertiary industry employment, concentrated mainly in wholesale/retail and business services.

Figure 3 [Figure 3: see original paper] illustrates the digital economy' s employment effects across different manufacturing and service sectors. Results show that the digital economy substantially impacts employment in technology-intensive manufacturing and producer services, driving 51.1% of technology-intensive manufacturing employment and 75.3% of producer services employment in 2016. Meanwhile, digital economy-driven manufacturing employment grew at an average annual rate of 12.8%, while service employment growth reached 20.9%. The close relationship between producer services and manufacturing explains how digital economy development maximizes the dual employment absorption effects of both sectors.

From an education perspective, the digital economy primarily affects workers with junior high and high school education. In 2016, junior high school-educated workers accounted for 41.2% of digital economy-driven non-agricultural employment, high school-educated workers 23.5%, and university undergraduate and above only 12.4%. Over time, the shares of junior high and high school-educated workers are decreasing while college and undergraduate+ shares are rising rapidly: the college share increased by 0.48 percentage points and undergraduate+ by 0.36 percentage points from 2014 to 2016. This explains why the digital economy affects more non-ICT industries such as catering, wholesale/retail, and transportation that primarily employ junior high and high school-educated workers, while its impact on higher-education groups in high-tech sectors like software is also increasing annually.

From an age structure perspective, digital economy-driven employment exhibits youthful characteristics, primarily pulling in the "post-90s" generation. As Figure 4 [Figure 4: see original paper] shows, workers aged 16-34 constitute the main group in digital economy-driven non-agricultural employment, accounting for 53.5% of the total compared to only 43.4% in national non-agricultural employment. The 25-29 age group particularly stands out, representing 17.3% of digital economy-driven employment—3 percentage points higher than the national share. Meanwhile, the 16-34 age group' s share in digital economy-driven employment decreased from 55.1% in 2014 to 53.4% in 2016, indicating that workers over 34 are gradually increasing their share, especially those aged 40-49. This reflects improving acceptance of the digital economy among middle-aged workers.

4. Conclusions and Policy Recommendations

Against the backdrop of vigorous digital economy development, this study innovatively constructs a non-competitive employment input-occupancy-output model distinguishing ICT industries and the digital economy, providing empirical analysis of China' s digital economy scale and its impacts on value-added and employment. Results demonstrate that the digital economy significantly affects both value-added and employment, with its contribution to GDP rising from 14.3% in 2014 to 16.0% in 2015 and 17.3% in 2016, while its share of non-agricultural employment grew from 15.2% to 20.2% during the same period. Digital economy development has thus become a new driver of China' s economic and non-agricultural employment growth.

(1) From an industrial structure perspective, ICT industry development should be a key focus for current industrial development and employment stabilization. Priority should be given to sectors such as communication equipment, computer and other electronic equipment manufacturing, and wholesale/retail trade. Leveraging internet technology-driven characteristics, we should accelerate innovation in new technologies, models, and industries within these "priority" sectors. Research shows that ICT industries exhibit high influence and sensitivity coefficients, indicating their critical role as the digital economy core in national economic development. ICT development not only increases demand for other sectors'products but also enhances other sectors' production capabilities. Comparison with non-ICT industries reveals that ICT industries' complete value-added coefficients far exceed those of non-ICT industries while complete employment coefficients are lower, demonstrating significant differences in intermediate use structures. ICT industries can accelerate national economic advancement while driving employment in other traditional industries.

(2) From a consumption structure perspective, education, entertainment, healthcare, and related sectors will be future economic growth points. We should leverage employment absorption in internet education, mobile healthcare, big data services, and "Internet+" wholesale/retail trade and software services. Research indicates that digital economy network consumption concentrates in online shopping, with online travel comprising a large share in other categories. Online travel, local lifestyle O2O (online-to-offline), catering, online education, and internet advertising have become key areas stimulating domestic demand and emerging industry development. These sectors will lead new consumption growth waves in both digital and traditional economies.

(3) From an employment structure perspective, China' s digital transformation will enhance productivity and accelerate innovation, requiring accelerated vocational skill development and human capital transformation from low-cost to skill-based advantages to cultivate higher-skilled workforces. Results show the digital economy generates significant youth effects and manufacturing intensity effects. On one hand, digital economy-driven employment concentrates among 20-29 year-olds, substantially exceeding traditional non-agricultural employment shares for this age group. On the other hand, digital economy-driven jobs concentrate in technology-intensive manufacturing and producer services, positively promoting manufacturing development. Therefore, we should establish cross-disciplinary three-dimensional talent training systems, build mid-to-high-end labor market supply-demand matching platforms and professional talent databases, and emphasize the digital economy' s role in driving employment for other labor forces.

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